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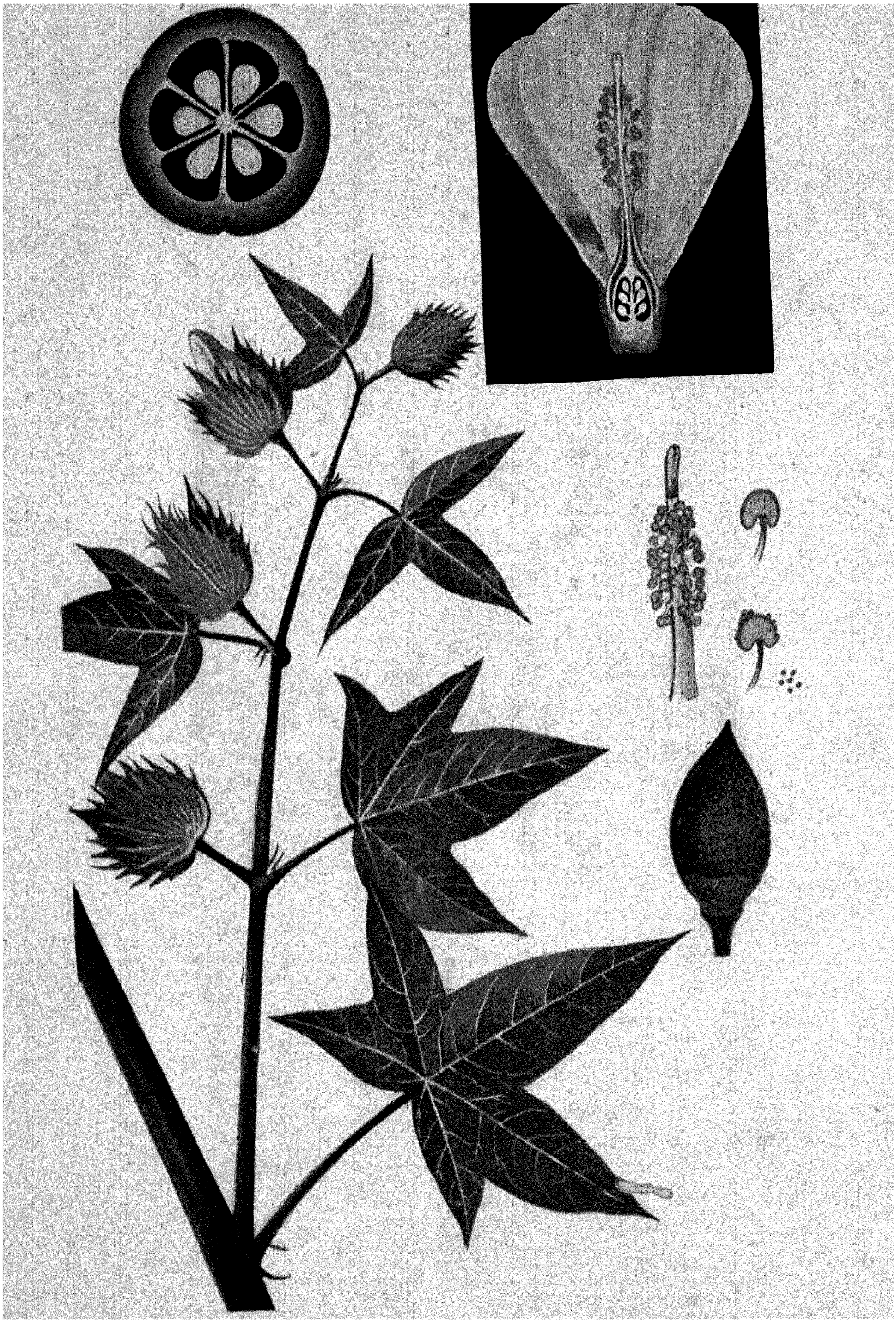
COTTON IN INDIA

A MONOGRAPH



GOSSYPIUM BARBADENSE—SEA ISLAND 'ANDREWS'

COTTON IN INDIA

A MONOGRAPH

Authors

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Published by

INDIAN CENTRAL COTTON COMMITTEE
BOMBAY

FIRST PRINTED IN FEBRUARY 1961

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Published by Dr. B. L. Sethi, M. Sc., Ph. D. (Wales), Secretary, Indian Central Cotton Committee,
14, Nicol Road, Ballard Estate, Bombay-1, and Printed by Rev. Theodore A. Pereira at
the Examiner Press, Medows Street, Fort, Bombay-1.

INTRODUCTION

The Indian Central Cotton Committee at its meeting held in February, 1956, endorsed the recommendation of its Policy Sub-Committee that a Monograph on Cotton might be published with a view to making available to the various educational and research institutions, the enlightened cotton growers and all others connected with cotton, a standard book of reference giving in simple form a comprehensive account of cotton in all its aspects on a region-wise basis. Subsequently, a small Sub-Committee discussed at length the divergent aspects concerning its publication and recommended that it should consist of four volumes comprising the following chapters:

Volume I : History of Cotton; Climate and Soils; Taxonomy; Morphology; Embryology; Breeding; Cytology; and Genetics.

Volume II : Physiology; Agronomy; Diseases; Insect and Mite Pests; and Seed Multiplication and Distribution.

Volume III : Technology; Ginning and Pressing; Marketing; Consumption of Cotton Seed; Consumption of Cotton Lint; Legislative Measures; and Exports and Imports.

Volume IV : Northern *hirsutum-arboreum* Region; Central *arboreum* Region; Sourthern *hirsutum-arboreum* Region; Central *herbaceum-arboreum-hirsutum* Region; Western *herbaceum* Region; and Eastern Region.

The First Volume was accordingly issued in February, 1960, followed by the Second Volume in July and the Third Volume in October of the same year. With the issue of this Fourth Volume, the publication of the Monograph is complete, thus fulfilling a long cherished desire. Judging from the response to the first three volumes, the Indian Central Cotton Committee is confident that the Fourth Volume will also be welcomed by all interested in cotton.

Topics such as history of cotton, its cultivation, botany, breeding, physiology, technology, processing, marketing, imports, exports, etc., had been dealt with in the first three volumes. The present volume describes the cultivation and other problems of cotton in different regions of the country. It is recognised that based on the soil-climate-variety complex, the country can be divided into the following six regions:

(*i*) Northern *hirsutum-arboreum* Region comprising Punjab, Western Uttar Pradesh, Delhi and North-West Rajasthan.

(*ii*) Central *arboreum* Region comprising Madhya Pradesh, South Rajasthan, South Saurashtra of Gujerat, and Khandesh, Vidarbha and Marathwada regions of Maharashtra.

(*iii*) Southern *hirsutum-arboreum* Region comprising Madras and Kerala.

(*iv*) Central *herbaceum-arboreum-hirsutum* Region comprising Andhra Pradesh and Mysore.

(*v*) Western *herbaceum* Region comprising Gujerat and part of Mysore.

(*vi*) Eastern Region comprising Assam, Manipur, Tripura, Orissa and Bihar.

In order to tackle the problems of not only cotton but its rotation crops, viz., Oilseeds and Millets as well, on a regional basis transcending the political boundaries, Regional Research Centres have also been established in all the above regions, except the last one. Steps are under way to establish Regional Centres to cater to this region also. Plant photographs of the different varieties of cotton grown in these regions have been reproduced in the earlier volumes.

The material on the different regions for this volume has been contributed by Dr. S.M. Sikka, Dr. Arjan Singh, Sarvashri Avtar Singh, P.D. Gadkari, R. Balasubrahmanyan, N. Kesava Iyengar, V. K. Bederker, G. B. Patel, P. S. Pandya, V. N. Paranjpe, S. R. Panigrahi and late Shri K. Sawhney. The Indian Central Cotton Committee is grateful to all these authors for their co-operation and the pains taken by them in presenting the material in a comprehensive manner.

I must express my profound gratitude to Dr. M. S. Randhawa, ex-President of the Indian Central Cotton Committee, who inspired the printing of this Monograph and but for whose constant encouragement and guidance its publication would not have materialised.

I must also record my gratitude to the members of the Indian Central Cotton Committee, particularly the Vice-President, Shri Madanmohan R. Ruia and Sarvashri R. G. Saraiya, Chunilal B. Metha and Chimanlal B. Parikh for their valuable suggestions and encouragement.

The jacket of this volume was designed by Shri N. S. Bisht, Director of Art, Indian Council of Agricultural Research, whose help is acknowledged with thanks.

Lastly, my thanks are due to the staff of the Committee particularly those of the Monograph Section for their zeal in completing this Monograph.

B. L. SETHI
Secretary
Indian Central Cotton Committee

Bombay
February 1961

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CHAPTER I

NORTHERN *HIRSUTUM-ARBOREUM* REGION

INTRODUCTION

According to Sethi and Dharmarajulu (1957), the cotton-growing tracts of India have been divided into six ecological regions. Out of them, the Northern *hirsutum-arboreum* Region is composed of the Punjab, western Uttar Pradesh, Delhi and Sriganganagar district of Rajasthan. Cotton is an important cash crop of the region, in the cropping pattern its place being next to wheat. In the western part of the region, where irrigation facilities are available, and the soil and climate are suitable for the crop, it is grown on 15 to 20 per cent. of the total area of a holding. In other parts, its intensity is less. The cotton acreage of the entire region forms 7.6 per cent. of the total cotton area of India, but, in production, it contributes over 18 per cent.

Two species of cotton, viz., *arboreum* (*desi*) and *hirsutum* (Punjab-American) are grown in the region. About two decades back practically the entire cotton-growing areas of the region grew exclusively *arboreum;* but due to increased availability of irrigational facilities and evolution of suitable strains of *hirsutum* for the region, great expansion under the acreage of *hirsutum* types has taken place in recent years. At present more than 60 per cent. of the total cotton acreage consists of *hirsutum* varieties and the growing of *arboreum* has assumed secondary importance.

The region is served by a net-work of canals. The highest gravity dam in the world, the Bhakra Dam, is near completion, and this will further improve the present irrigational facilities, and also provide water to vast new areas in the Punjab and Rajasthan. Because cheap water is available from the canals, more than 90 per cent. of the cotton area is served by irrigation, and consequently the per acre yield is the highest in India, the actual figures being 180 and 77 lb. of lint per acre for the Northern Region and the all-India average, respectively. As compared to the per acre yield of the other important cotton-growing countries, i.e., 497 lb. in U.S.S.R.; 428 lb. in Peru; 417 lb. in U.S.A.; 391 lb. in Egypt and 352 lb. in the Sudan, the yield in the Northern Region is very low; but there is positive scope for improving it by means of intensive cultivation methods.

Cotton is grown in the region as a *kharif* crop; sowings take place during April-May and the major portion of the crop is harvested during October-November. The growing period of the crop is limited as a result of the cold weather which sets in from the end of November onwards, when the occurrence

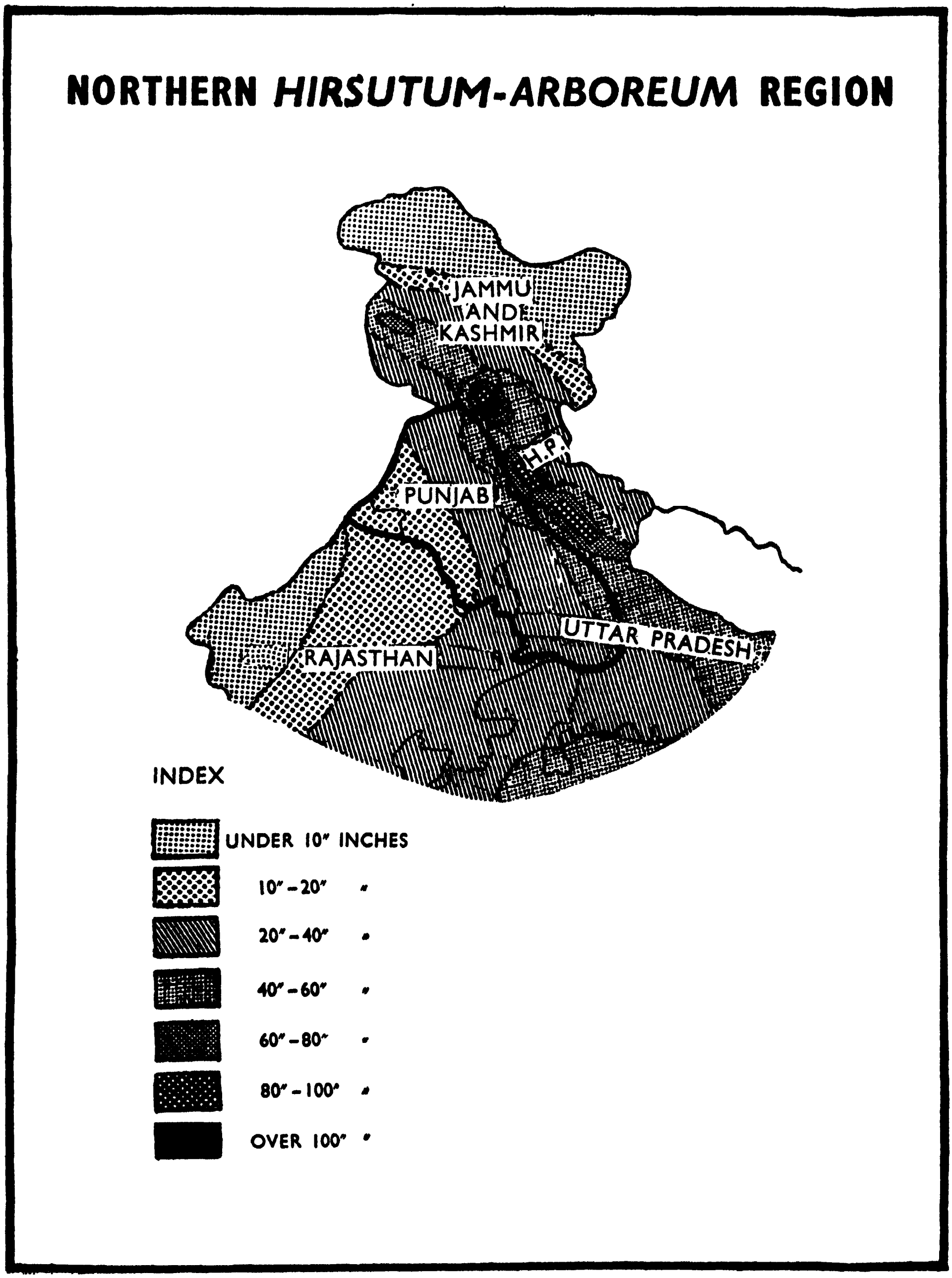


Fig. 1. Rainfall Pattern of the Northern Region

of frosts is quite common. The summer is severe, during which the crop is exposed to great water stress, because of the prevalence of hot and strong winds, and high temperature, which very often goes above 110°F. and sometimes even touches 116°F. during the months of May and June. Most of the rain is received during the monsoon period, viz., July-September. The rainfall varies from 5 to 35 inches in the various parts of the region (Fig. 1). The areas with scanty rainfall, but with assured water supply from the canals are comparatively more productive of cotton in the region.

The soils in the region are of alluvial origin, their depth being usually 10 feet. The soils are mostly flat. Their physical texture varies from sandy loam to clay loam; the former are met with mostly in low rainfall areas and the latter in the areas with higher rainfall. On the whole, all the soils are productive and retentive of moisture. They suffer from deficiency of nitrogen and organic matter, the latter component being particularly more deficient in areas of low rainfall. The soils are generally alkaline in reaction, the pH going up to 8.5 in some tracts. Some soils contain an excess of calcium carbonate, which is sometimes present in nodular form, locally known as *kankar*.

AREA AND PRODUCTION

The Northern *hirsutum-arboreum* Region, perior to the partition of the country, included the fertile plains of West Punjab and Sind. Here, cotton covered an area of 40 lakh acres, forming 27 per cent. of the total cotton acreage of the Indian sub-continent and contributing 45 per cent. to its total production. The quality of cotton produced was also superior. Out of 30.38 lakh bales of medium and long staple cotton produced in undivided India, 13.58 lakh bales, viz., 44 per cent. came from the Northern Region. In fact, none of the other five cotton-growing regions of India was so important as the Northern Region both in respect of the quantity and the quality of cotton.

Effect of Partition. The partition of the country • in August, 1947, reduced the Northern Region to a minor position in cotton production. The fertile, rich cotton-growing areas of Sind, West Punjab, Bahawalpur and Khairpur were cut off and added to Pakistan, with the result that in the truncated Northern Region, the acreage of cotton fell from 40.05 lakh to 8.30 lakh acres and the production was reduced from 19.08 lakh to 3.08 lakh bales. The production of medium and long staple cottons was also reduced from 13.8 lakh to 0.28 lakh bales. The effect of partition on the cotton position in the Northern Region is summarised in Table 1.

The poor position to which the resultant Northern *hirsutum-arboreum* Region was thus reduced created a serious situation not only for the farmers of the Northern Region, but also for the entire spinning industry of the Indian Union.

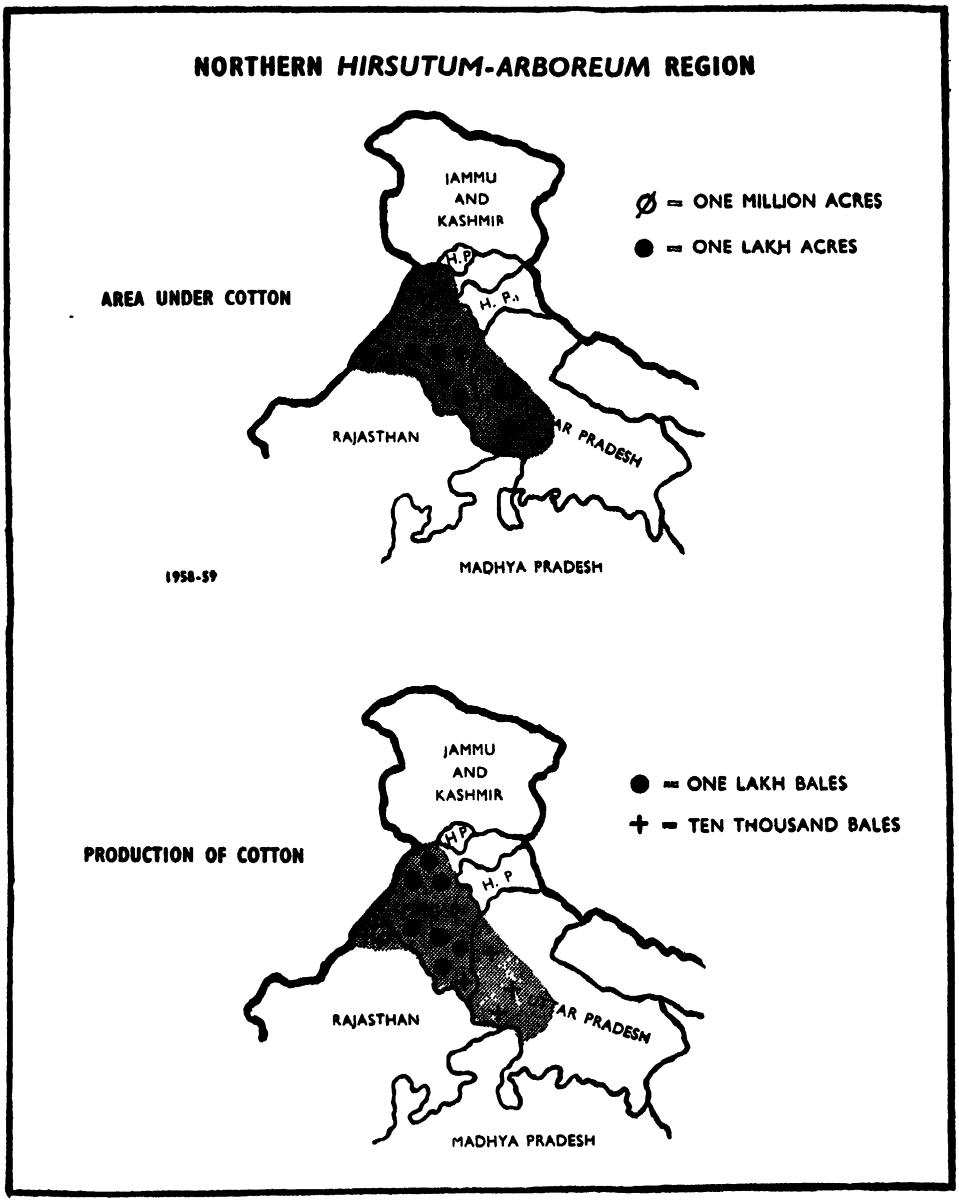


Fig. 2. Intensity of Area and Production of Cotton in the Northern Region—1958-59

TABLE 1. EFFECT OF PARTITION ON COTTON POSITION IN THE NORTHERN REGION

Particulars	Pre-partitioned Northern Region	Pakistan part of Northern Region	Indian part of Northern Region	Indian Union	Undivided India
Acreage of cotton (thousand acres)	4,005	3,175	830	10,841	14,846
Percentage of Undivided India	27·0	21·4	5·6	73·0	—
Production (thousand bales)	1,908	1,600	308	2,292	4,200
Percentage of Undivided India	45·4	38·1	7·3	54·6	—
Production of medium and long staple cottons (thousand bales)	1,358	1,330	28	1,722	3,080
Percentage of Undivided India	44·1	43·2	0·9	55·9	—

Revival in Acreage and Production. To mitigate the situation, a number of research schemes were launched by the State Department of Agriculture with the financial aid of the Indian Central Cotton Committee, with a view to studying the possibility of increasing the area and production of cotton in the region, investigating the methods of cotton cultivation and developing new varieties, superior to the existing ones. In 1950, the Cotton Extension Scheme was launched by the Central Government to give momentum to cotton growing and to educate the growers in the methods of cotton cultivation. The seed distribution schemes made available seeds of pure and high yielding varieties. Progressively larger areas came under irrigation as a result of the major and minor irrigation projects started by the States. All these factors gave a great impetus to the growing of cotton and very gratifying results were achieved, as will be observed from Table 2 (Figs. 2 and 3).

TABLE 2. REVIVAL IN ACREAGE AND PRODUCTION OF COTTON IN POST-PARTITION PERIOD IN THE NORTHERN REGION

State	Acreage (thousand acres)		Production (thousand bales)	
	1946-47	1955-56	1946-47	1955-56
Punjab	578	1,282	223	605
N. W. Rajasthan	80	124	40	66
Uttar Pradesh	172	136	45	27
Total	830	1,542	308	698

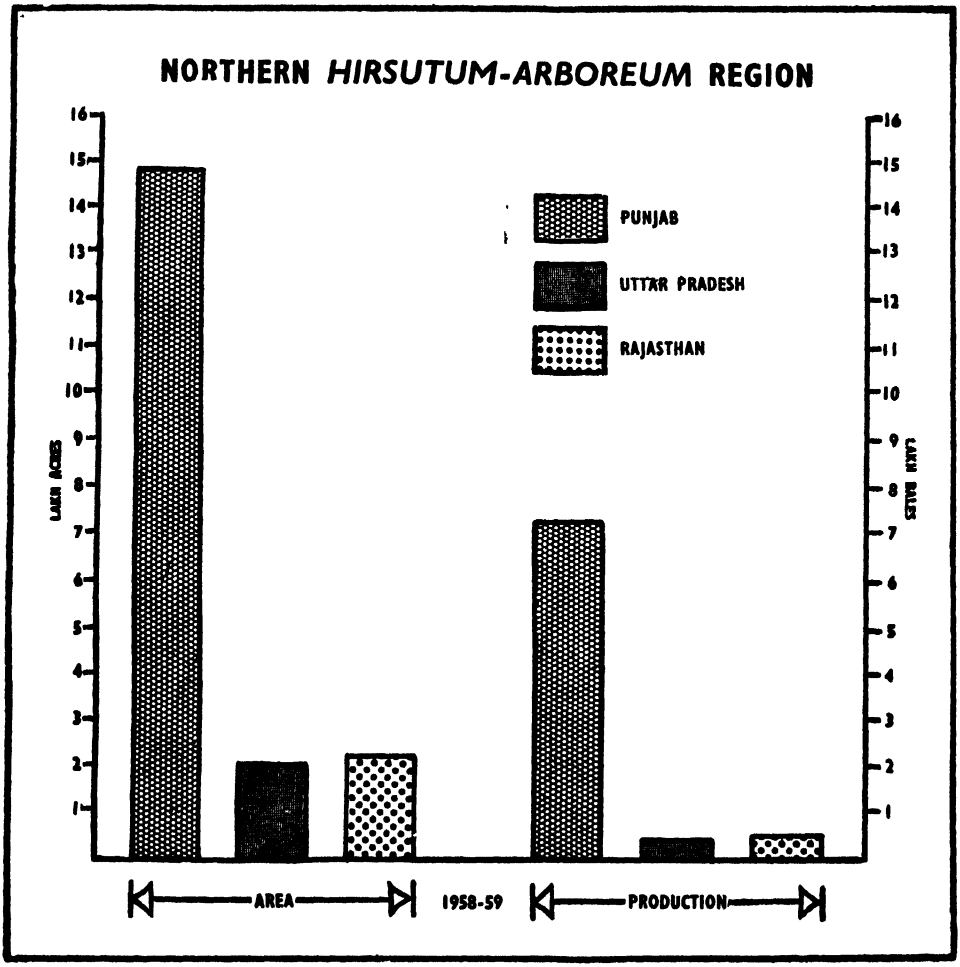


Fig. 3. Area and Production of Cotton in Different States of the Northern Region—1958-59

It will be seen that the acreage and production of cotton in the Northern Region increased from 8.3 lakh acres and 3.08 lakh bales in 1946-47, the pre-partition year, to 15.42 lakh acres and 6.98 lakh bales, respectively, in 1955-56. Position during the First and Second Five-Year Plan periods is depicted in Figure 4.

It will also be observed from the above figures that while cotton could not make any headway in Uttar Pradesh, there was a good deal of increase in the acreage and production in both North-west Rajasthan and the Punjab, though the increase was more spectacular in the latter. The figures given in Table 3 show that a further marked increase in the acreage and production of cotton has taken place in the Punjab after the year 1955-56.

TABLE 3. PROGRESS IN ACREAGE AND PRODUCTION OF COTTON SINCE PARTITION

Year	Acreage (thousand acres)	Production (thousand bales)
1946-47	578	223
1947-48	487	128
1948-49	417	139
1949-50	534	270
1950-51	693	371
1951-52	822	400
1952-53	809	435
1953-54	898	554
1954-55	1,189	613
1955-56	1,282	605
1956-57	1,415	800
1957-58	1,522	759

The up-to-date increase in the Punjab has been 264 per cent. in acreage and 340 per cent. in production over that of 1946-47, the pre-partition year. This has enabled the Punjab to regain, to a considerable extent, the position it had before partition. The data given in Table 4 show that the Punjab once again has begun to enjoy an important position amongst the cotton-growing States of India.

TABLE 4. STATUS OF THE PUNJAB IN COTTON GROWING STATES OF INDIA (1955-56)

State	Cotton acreage (thousand acres)	Percentage (all-India)	Cotton production (thousand bales)	Percentage (all-India)
Bombay	10,869	54	1,923	48
Punjab	1,282	6	605	15
Madhya Pradesh	2,324	11	419	10
Mysore	2,798	14	411	10
Madras	921	5	282	7
Rajasthan	590	3	163	4
Andhra Pradesh	1,195	6	140	4
Uttar Pradesh	136	0·6	27	1
Other States	115	0·4	28	1
Total	20,230	100	3,998	100

In acreage, the position of the Punjab is fourth, but in production it is second on the list, the latter position being due to its yield per acre—the highest amongst all the Indian States (Table 5)—and is primarily due to the irrigated status of 94 per cent. of the Punjab cotton crop.

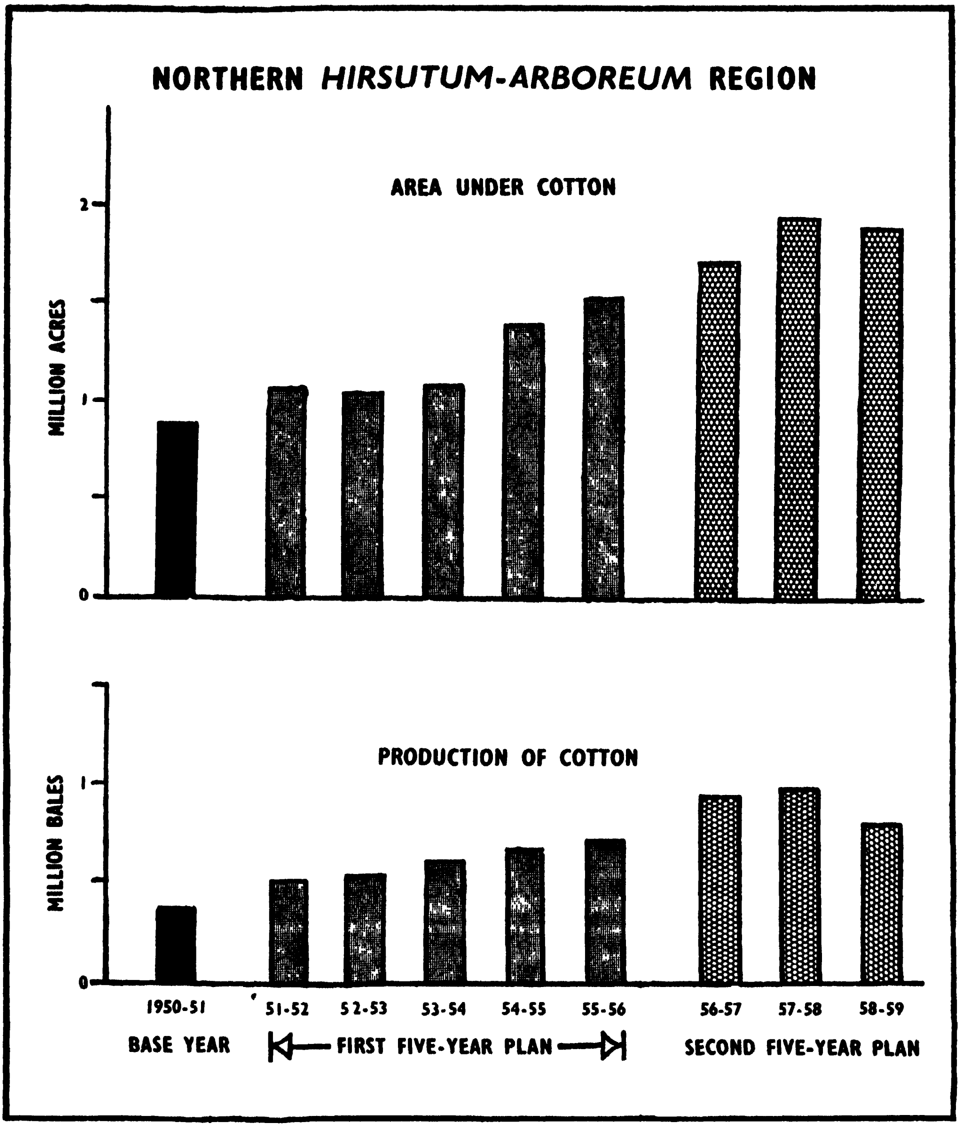


Fig. 4. Area and Production of Cotton During First and Second Five-Year Plan Periods in the Northern Region

TABLE 5. YIELD OF LINT PER ACRE IN INDIAN STATES

State	Lint yield per acre (lb.)				
	1951-52	1952-53	1953-54	1954-55	1955-56
Punjab	191	211	242	202	185
Madras	131	114	124	122	120
Rajasthan	92	111	108	97	108
Madhya Pradesh	56	74	78	72	71
Bombay	70	72	85	88	69
Mysore	54	56	65	57	58
Andhra Pradesh	56	49	39	41	46
All-India (average)	76	80	90	89	77

It will be observed that in the Punjab the per acre yield is three times the all-India average. In recent years, there has been a further increase, being 221 lb. and 196 lb. per acre for the years 1956-57 and 1957-58, respectively, in spite of unfavourable weather conditions. These yield figures are of special interest, as they denote a higher yield than that of even West Punjab where the average production of 141 lb. to 180 lb. of lint per acre was recorded during the pre-partition period, viz., 1937-45 (Afzal *et al.*, 1948). This achievement in Indian Punjab is creditable, particularly when it is considered that agricultural and climatic conditions in West Punjab are more congenial for the cotton plant, and that that part of the country was better developed and had a superior canal system as compared to the portion of the Punjab that came to India.

Revival in Quality. In the pre-partition year, 1946-47, out of the total production of 3,08,000 bales of cotton in the Northern Region, only 28,000 bales (i.e., 9 per cent.) were medium-stapled. The only medium-stapled variety grown in that year was L.S.S., which has the staple length of 26/32 to 28/32 inches and a spinning capacity of 24's counts. It was being grown in the Ferozepur and Bhatinda districts of the Punjab and hardly covered an area of 77,000 acres out of the total cotton area of 8,30,000 acres of the region. The rest of the area was mostly under short staple *desi* varieties, with a staple length ranging from 12/32 to 18/32 inches and the spinning capacity of 6's to 8's counts. Only in western Uttar Pradesh there existed a very small area under the improved *desi* variety, C.520, with a staple length of 20/32 to 22/32 inches and a spinning capacity of 12's counts.

Before partition, efforts were made to introduce the then prevalent medium and long staple varieties of American cotton into the central and south-eastern districts of the Punjab, but as these varieties could not be grown successfully, it was concluded that the soil and climatic conditions of these districts were not suitable for the growth of the American varieties. This belief, however, proved to be not well-founded, as by breeding the early-ripening varieties, chiefly 216F, 320F and H.14, and introducing them in the irrigated cotton-growing districts of the Punjab (India) a substantial portion of the short-stapled cottons could be replaced within a short span of about 10 years. The spectacular success which these new varieties attained is well brought out by the fact that by 1955-56, they came to occupy an area of 9,36,000 acres (61 per cent.) out of the total cotton acreage of 15,39,000 of the Northern Region. In Uttar Pradesh, a variety of *desi* cotton, namely 35/1, which is an improvement over the old Uttar Pradesh variety, C.520, and is classed in the medium-stapled group, came to occupy an area of 45,000 acres.

The improvement in quality which the new varieties brought about in the cotton crop of the Northern Region is shown in (Fig. 5) Table 6.

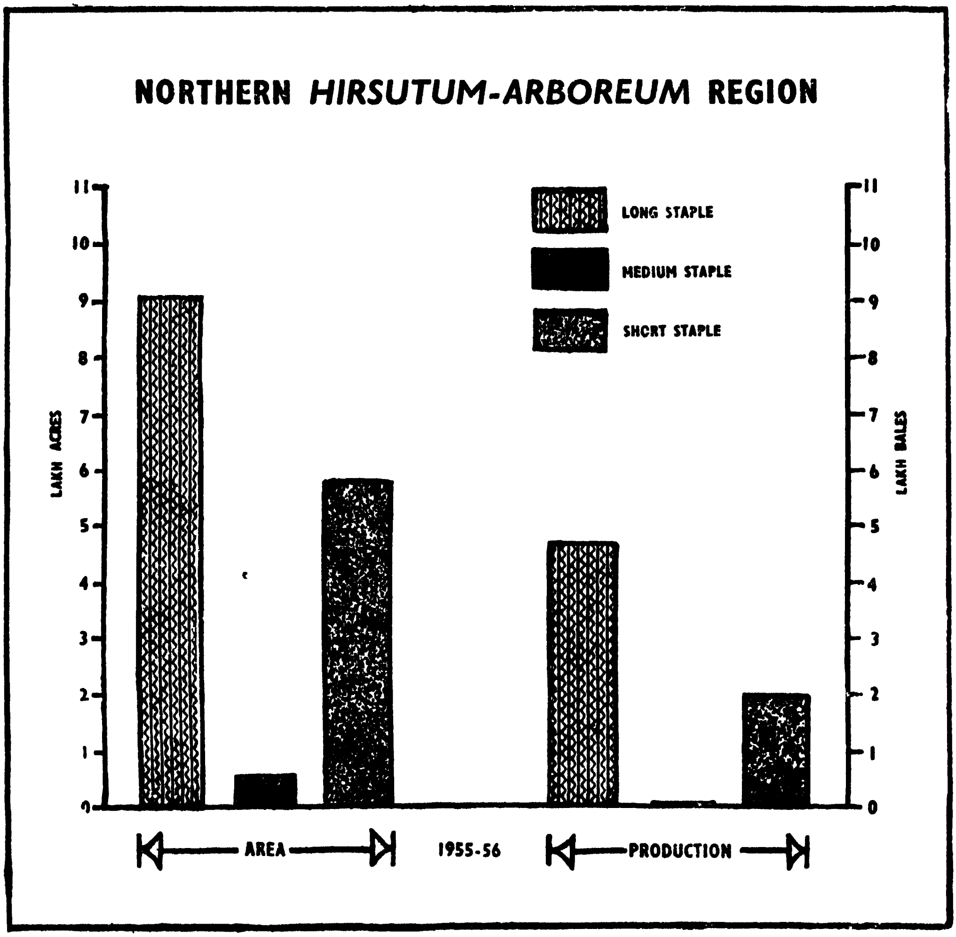


Fig. 5. Area and Production of Cotton According to Different Staple Lengths in the Northern Region

TABLE 6. PRODUCTION OF COTTON IN THE NORTHERN REGION CLASSIFIED INTO VARIOUS STAPLE LENGTHS (1955-56)

Staple length	Production (thousand bales)				
	Northern Region	Percentage of India	Rest of India	Percentage of India	Total in India
7/8" and above	409	26·0	1,168	74·0	1,577
Below 7/8" and above 11/16"	106	6·0	1,675	94·0	1,781
Below 11/16"	183	27·6	479	72·4	662
Total	698	17·4	3,322	82·6	4,020

It will be observed that out of the total Indian production of 15,77,000 bales of long staple cotton, with a lint length of 7/8 inch and above, 4,09,000 bales, viz., 26 per cent. were contributed by the Northern Region, whereas, at the time of partition, such cottons formed only 0.9 per cent. (Table 1) of the total cotton crop.

Though the quality of the cotton crop in all constituent States of the Northern Region showed improvement, the most marked and rapid change took place in the Punjab State, as will be seen from the data given in Table 7.

TABLE 7. IMPROVEMENT IN THE QUALITY OF COTTON CROP

Year	Production (thousand bales)			Total production	Average* staple length (inches)
	L.S.S.	216F-320F	Desi		
1947-48	9	—	119	128	0·629
1948-49	17	—	122	139	0·635
1949-50	55	—	215	270	0·665
1950-51	103	3	265	371	0·682
1951-52	100	26	274	400	0·697
1952-53	117	69	269	435	0 731
1953-54	83	248	223	554	0·789
1954-55	54	388	171	613	0·830
1955-56	71	384	150	605	0·838
1956-57	60	560	180	800	0·847
1957-58	49	462	248	759	0·816

* The average staple length has been worked out on the basis that mean length of L.S.S., 216F and *desi* is 0·88", 0·92" and 0·61", respectively.

It will be observed that, to start with, the mean staple length of the cotton crop in the Punjab was 0.629 inch, but over the short period of a decade, it went up to 0.816 inch. The Punjab, as a producer of long staple cotton, has now come to occupy second position in India, the pride of first place going to Bombay (Table 8).

TABLE 8. STATEWISE PRODUCTION OF COTTON UNDER DIFFERENT STAPLE LENGTH GROUPS

State	Production (thousand bales)			Total
	Long staple (7/8" and above)	Medium staple (below 7/8" and above 11/16")	Short staple (below 11/16")	
Bombay	551	722	10	1,283
Punjab	384	71	150	605
Madhya Pradesh	94	210	149	453
Hyderabad	145	124	59	328
Madras, Andhra, Mysore	361	78	64	503
Other States	42	576	230	848
Total	1,577	1,781	662	4,020

It is interesting to observe that, while in Bombay, the long staple cottons formed 43 per cent. of the total cotton production of the State, in the Punjab State its percentage was 63. Apparently, better conditions exist for growing quality cottons in the Punjab State.

COTTON ZONES, THEIR CLIMATE AND SOIL

The Northern *hirsutum-arboreum* Region, lying in the Indo-Gangetic plains of northern India, is almost trapzoid in shape and has a maximum length and breadth of 440 and 170 miles, respectively. The soils, climate and rainfall vary a good deal in the Region and on the basis of the varieties observed, it can be divided into four distinct zones, as shown in Figure 6. A brief account of the different zones is given below :

SOUTH-WESTERN ZONE

This zone comprises the Ferozepur and Bhatinda districts of the Punjab and Sriganganagar tract of Rajasthan. The whole of this zone is commanded by a net-work of perennial canals. The annual rainfall ranges from 5 to 12 inches. Frosts during the month of January are quite common. During summer, the maximum temperature occasionally goes up to 116°F. and is accompanied by hot, dry and desiccating winds.

The soils of this area are mostly light loam, with high proportion of fine sand in them, well-drained and very suitable for cotton cultivation. They are alkaline in reaction, the pH going up to 8.5, besides being poor in nitrogen content and organic matter. The analytical data pertaining to a typical soil sample of this region are given in Table 9 (Negi and Kanwar Singh, 1956 b).

Cotton is the chief crop of the tract. In fact, this is the most important zone from the cotton-growing point of view in the Northern Region, as it contributes 53 per cent. to the total production of the region. Because

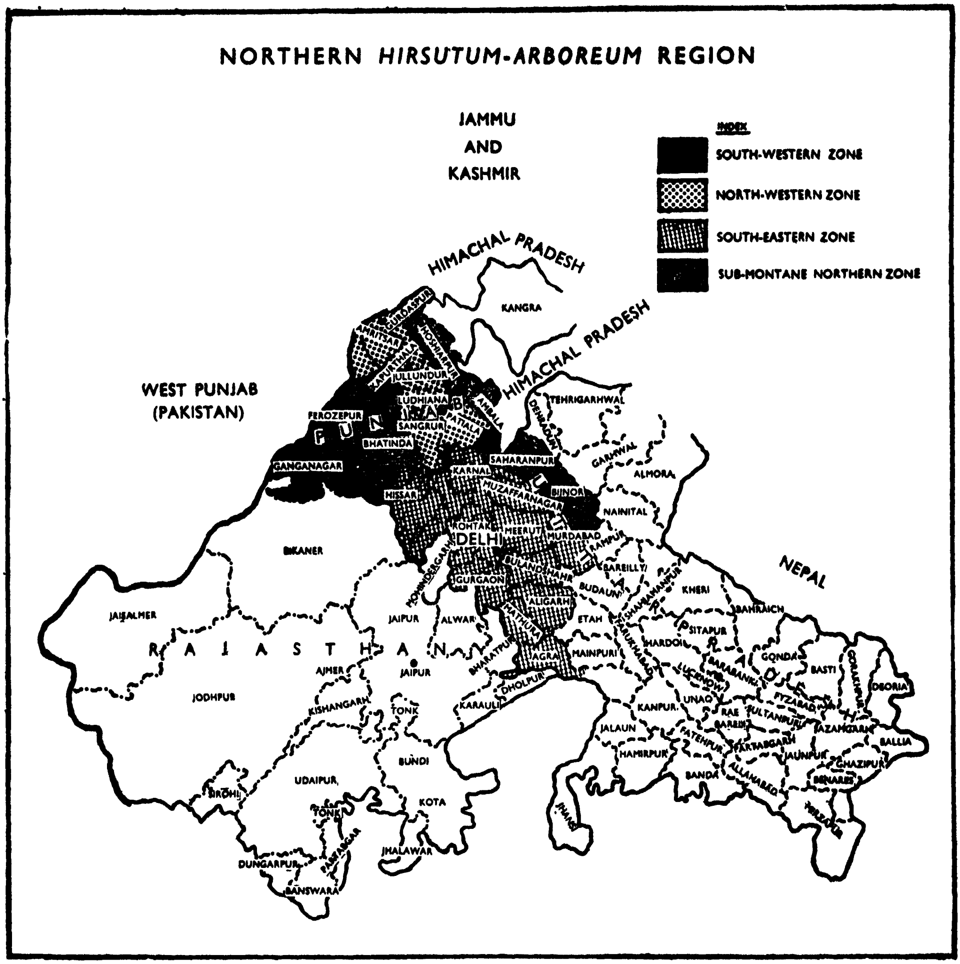


Fig. 6. Four Different Zones of the Northern Region

TABLE 9. ANALYSIS OF SOIL AT ABOHAR (FEROZEPUR DISTRICT)

Depth (inches)	Per cent. on air dry basis							
	$CaCo_3$	Organic carbon	Total nitrogen	Available P_2O_5 (mgs.)	Coarse sand	Fine sand	Silt	Clay
0— 6	3·0	0·320	0·070	48	1·3	72·4	12·3	10·6
6—12	6·3	0·240	0·042	42	1·5	67·3	14·8	9·9
12—24	10·4	0·320	0·028	38	2·4	61·4	16·2	9·3
24—36	10·3	0·128	0·032	36	2·2	64·2	14·4	8·9
36—48	8·0	0·104	0·032	40	2·9	64·6	16·3	8·1
48—60	10·0	0·120	0·032	42	3·2	63·1	17·0	6·5
60—72	12·0	0·240	0·025	38	3·5	60·7	17·3	6·2

the tract is arid with an assured water supply from the canals, the best cottons of the Punjab are grown here. Out of the total acreage of 6,66,000 in 1955-56 under cotton, an area of 4,46,000 acres (67 per cent.) was devoted to the American varieties and the remaining 2,20,000 acres (33 per cent.) were occupied by *desi* varieties. *Desi* cotton is grown mostly for domestic use on marginal lands where irrigation water is the limiting factor. The Punjab-American, 320F, is the premier variety grown, covering nearly 70 per cent. of the total area under American cottons. In a small pocket of this tract, round about Fazilka *tehsil* of Ferozepur district, the old variety, Punjab-American, L.S.S., is still under cultivation, as here irrigation water is available in adequate quantities, which suits it better on account of its late-ripening habit. Very recently an extra-long linted variety, namely LL. 54, has been released in this zone and is expected to do well.

The diseases and pests are usually of minor occurrence, but jassid (*Empoasca devastans* Dist.) becomes serious in some years.

NORTH-WESTERN ZONE

This zone is comprised of the districts of Amritsar, Jullundur, Ludhiana, Patiala and part of Sangrur. Irrigation is available from wells and canals. The annual rainfall varies between 20 and 30 inches. The occurrence of frosts is common during winter months, but the summer is not very severe; the maximum temperature goes beyond 110°F. for a very short duration only. Hot and dry winds prevail, but their duration and severity are much less as compared to the South-western zone. Sometimes rains fall during September and October, impairing the yield and quality of the produce.

The soils of the area are mostly light loam with a high proportion of fine and coarse sand. The proportion of silt is also fairly high in them. They are easily workable with ordinary cultivation implements and are well-drained. They are alkaline in nature, with pH ranging from 7.0 to 8.5. They are deficient in nitrogen content and organic matter. Analytical data of a soil sample from Jullundur, which is situated in the middle of this zone, is given in Table 10 (Negi and Kanwar Singh, 1956 b).

TABLE 10. ANALYSIS OF SOIL AT JULLUNDUR

Depth (inches)	Per cent. on air dry basis							
	$CaCo_3$	Organic carbon	Total nitrogen	Available P_2O_5 (mgs.)	Coarse sand	Fine sand	Silt	Clay
0— 6	0·40	0·677	0·088	300	32·6	39·3	21·1	6·4
6—12	0·15	0·320	0·077	100	34·3	40·6	17·9	6·9
12—24	0·10	0·272	0·084	37	31·3	46·6	17·5	5·4
24—36	0·35	0·211	0·042	31	35·6	41·9	16·5	5·6
36—48	0·11	0·204	0·077	29	37·8	40·6	16·4	5·7
48—60	0·06	0·191	0·067	29	35·7	41·9	17·9	4·8
60—72	0·15	0·143	0·056	28	36·0	43·3	16·5	4·5

Before partition, cotton was of minor importance in this zone. Only *desi* cotton was grown, mostly for home consumption. After partition, the evolution of the American variety, 320F, made growing of cotton on a commercial scale popular, and this variety now covers 65 per cent. of the total cotton area in the zone. This zone contributes 23 per cent. to the cotton production of the Northern Region and is second in importance in this respect.

As the climate of this zone is mild and humid, the cotton crop suffers from many pests and diseases. Jassids appear almost every year. Bollworms in certain seasons become quite serious and the incidence of leaf roller becomes wide-spread occasionally. In the years of heavy rainfall, angular leaf spot damages the crop. The result is that the final yield of crop in this zone is not in consonance with the vegetative growth it makes, and many a time, the quality is also impaired.

SOUTH-EASTERN ZONE

This zone comprises Hissar, Rohtak, Gurgaon, Karnal and part of Sangrur district of the Punjab and Bulandshahr, Mathura, Meerut, Muzzaffarnagar, Moradabad and Agra districts of Uttar Pradesh. Some parts of the tract are already canal-irrigated, but water duty will improve and irrigation extended to new areas from the irrigation projects that are under way. The rainfall ranges from 15 to 35 inches.

The climate during summer is hot. The maximum temperature sometimes touches 115°F., which is usually attended by hot and dry winds during the months of May and June. Duststorms are common. Sometimes untimely rains fall during September and October and cause deterioration in yield and quality. Frost is rare.

The soils are usually medium loam, but vary from light to heavy loam, with quite a high percentage of silt and clay. The analysis of a typical soil of Hansi (Hissar district) is shown in Table 11 (Negi and Kanwar Singh, 1956 b).

TABLE 11. ANALYSIS OF SOIL AT HANSI (HISSAR DISTRICT)

Depths (inches)	Per cent. on air dry basis							
	$CaCo_3$	Organic carbon	Total nitrogen	Available P_2O_5 (mgs.)	Coarse sand	Fine sand	Silt	Clay
0— 6	0·7	0·248	0·060	80	0·26	57·8	24·7	16·3
6—12	4·6	0·144	0·046	36	0·37	55·6	23·0	16·3
12—24	8·1	0·176	0·042	38	0·22	50·4	23·1	17·7
24—36	8·0	0·184	0·038	48	0·49	45·5	21·6	25·3
36—48	9·9	0·184	0·035	46	0·58	55·1	19·9	15·0
48—60	8·1	0·168	0·038	40	0·60	55·2	18·7	17·2
60—72	5·0	0·160	0·035	38	0·63	59·7	18·9	15·6

The high proportion of calcium carbonate in the soils, gives them an alkaline reaction, with pH value of about 8.5. It also occurs in many places in the form of *kankar*. The soils are poor in organic matter and nitrogen.

In the Punjab part of this zone, early efforts to introduce American cotton met with utter failure; likewise, in Uttar Pradesh, Perso-American was introduced, but it could not make much headway. However, after partition the development of short-duration varieties, P.A. 216F and P.A. H.14, made the successful cultivation of American cotton possible in this zone, where formerly *desi* cotton was grown exclusively. The American varieties are very popular now. Already 70 to 75 per cent. of the total cotton acreage of this zone is covered by them. This zone is third in importance from the cotton-growing point of view in the Northern Region and contributes 21 per cent. to the total production.

The climate of this zone breeds the pink bollworm (*Platyedra gossypiella*) and leaf roller (*Sylepta derogata*). These are the two serious pests which chiefly impede the growth of American cotton. The latter insect is controlled by ordinary plant-protection measures, but the former, being an internal feeder in the boll, requires many sprayings for successful suppression, which become rather costly. If American cotton is to be maintained and further improved in this zone, it is imperative to enact and enforce a comprehensive piece of legislation for the control of this pest on the lines in vogue in Egypt.

In years of heavy rainfall, the angular leaf spot makes its appearance, but this disease seldom becomes serious.

SUB-MONTANE ZONE

This zone comprises the three districts of the Punjab, viz., Gurdaspur, Hoshiarpur and Ambala, and the three contiguous districts of Saharanpur, Bijnor and Rampur of Uttar Pradesh. Canal irrigation is not available here, but the rainfall ranges from 30 to 40 inches per annum, and is sometimes higher.

The climate is mild during the summer months, and the winters are cold. Frost during December and January is common. The soils are light to heavy loam in texture. They contain a low amount of organic matter and are poor in nitrogen. The soil reaction is neutral to alkaline, the pH ranging from 6.8 to 8.5.

This zone contributes three per cent. to the total cotton production of the region. Here, only *desi* cottons of low spinning value are grown, and the possibility of cultivating American cotton is rather remote. In the Punjab portion of this zone the varieties 39 Mollisoni and 231 Rosea are common. In Uttar Pradesh part of this zone selection 35/1 is under cultivation.

PHYSIOLOGY OF COTTON PLANT

Ever since Balls (1919) formulated the concept of plant scaffolding "upon which cotton is borne", growth studies on the vegetative organs of the plant have assumed great importance. Trought (1931 a, b) studied the effect of some meteorological factors, like rainfall, evaporating power of the atmosphere, soil temperature, maximum and minimum air temperatures and duststorms on the growth of Punjab-American, 4F, cotton grown at Lyallpur (West Punjab). Afzal (1949) and Dastur (1944) have also presented considerable data on the growth and other physiological aspects of the cotton plants. Their findings, however, do not have a direct bearing on the cotton crop of the Northern Region of India, as the varieties of cotton grown in this region and the climate and soil conditions are very different from those in West Pakistan. In view of this, it was of interest to compare the physiological peculiarities of the cotton varieties grown in the Northern Region with those observed by Trought, Afzal and Dastur. The results obtained in such studies are summarised in this chapter.

GROWTH

Iqbal Singh (Unpublished) studied the dry weight of plants at fortnightly intervals for seven varieties of cotton, five belonging to early group of American varieties, one late American cotton and one *desi* variety. Starting 45 days after sowing, he worked out the relative growth rate by using log W_2-log W_1 where W_1 and W_2 denoted total dry weight per plant at two successive stages of growth. He also worked out the net assimilation rate, which denoted the rate of increase in dry weight per unit leaf weight within a specified interval of time. The data recorded on both aspects are presented in Table 12 and depicted in a graph (Fig. 7).

TABLE 12. THE AVERAGE VALUES OF RELATIVE GROWTH RATE AND NET ASSIMILATION RATE FOR DIFFERENT VARIETIES IN THE PUNJAB (INDIA)

	Days after sowing							
	45	60	75	90	105	120	135	150
Relative Growth Rate								
L.S.S.	1·39	1·25	1·10	0·75	0·52	0·46	0·27	0·21
Early Americans	1·43	1·22	1·15	0·67	0·56	0·40	0·32	0·15
231R	1·36	1·31	1·10	0·79	0·62	0·37	0·26	0·17
Net Assimilation Rate								
L.S.S.	1·98	1·86	1·88	1·46	1·17	1·09	0·73	0·61
Early Americans	2·10	1·89	2·10	1·43	1·39	1·09	0·61	0·37
231R	1·90	2·00	1·91	1·59	1·68	0·81	0·74	0·53

It will be noted from the data in Table 12 that both the relative growth rate and net assimilation rate decline progressively with the advance in the age of the plant.

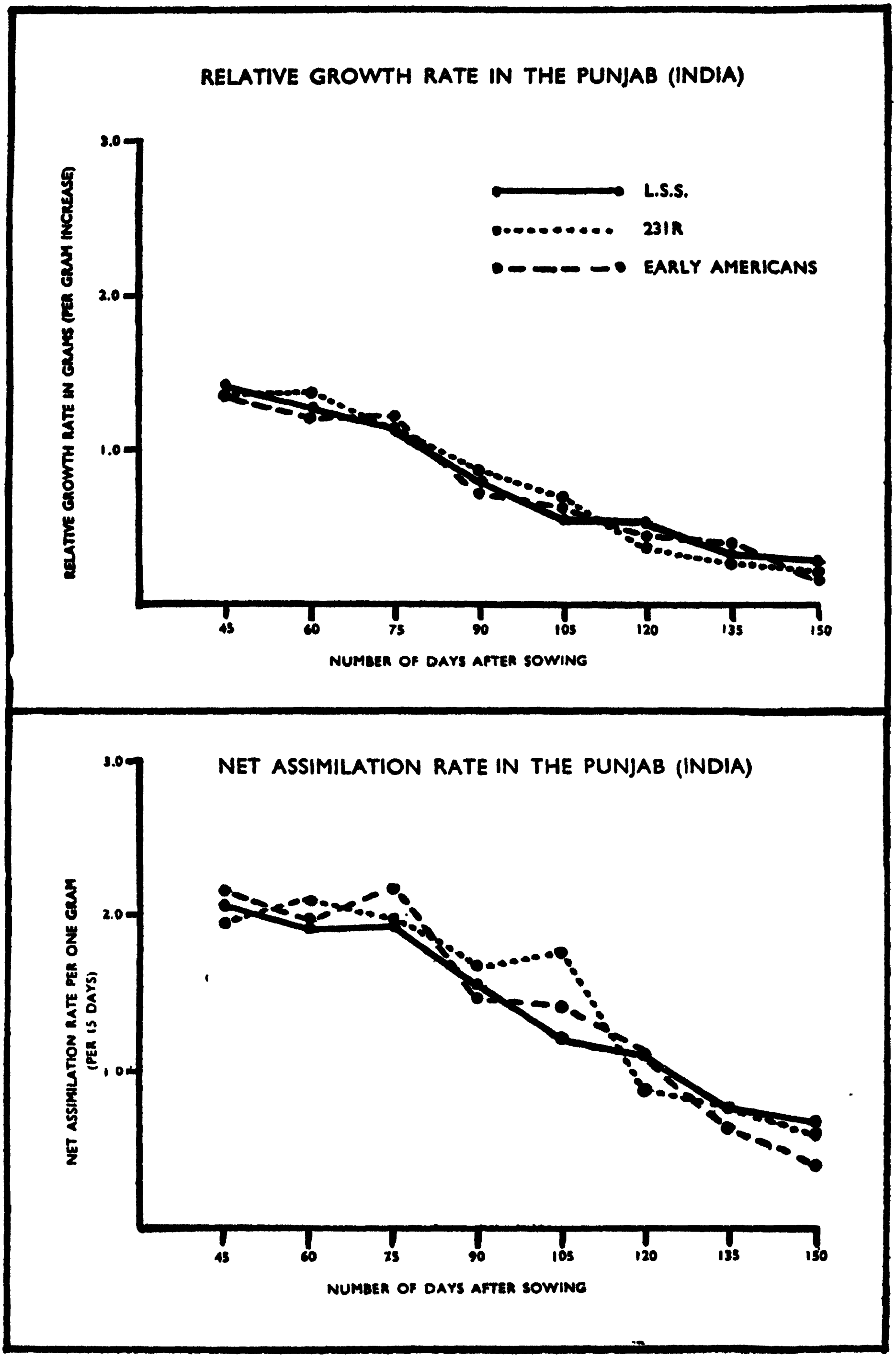


Fig. 7. Relative Growth Rate and Net Assimilation Rate in the Punjab (India)

The data obtained by Iqbal Singh on relative growth rate at Jullundur and Abohar (Punjab, India) can be compared with that obtained by Dastur at Hyderabad (Sind) and Iqbalnagar (West Punjab, Pakistan). Figure 8 depicts the position in this connection. It is observed that the relative growth rates are higher both at Jullundur and Abohar as compared to those recorded in West Punjab and Sind. It appears that the higher humidity, milder temperatures and higher rainfall prevailing in the Punjab (India) as compared with those in Sind and West Punjab (Pakistan) are responsible for this difference. This net result of the higher growth rate in the Punjab (India) is to make the cotton crop mature much earlier as compared to that in West Punjab (Pakistan). This is evident from the fact that, whereas the cotton crop in the Punjab (India) is mostly over by the end of November, the picking of the cotton crop in West Punjab (Pakistan) goes on up to the end of January.

The effect of five sowing dates extending from 31st March to 31st May was studied by Iqbal Singh. The data are presented in Table 13.

TABLE 13. THE AVERAGE VALUES OF RELATIVE GROWTH RATE UNDER DIFFERENT SOWING DATES (SEASONS 1950 AND 1951)

Date of sowing	May		June		July		August		September		October	
	15th	30th	14th	29th	14th	29th	13th	28th	12th	29th	12th	27th
D_1 31/3	1·33	1·13	0·76	1·02	0·91	0·38	0·82	0·33	0·15	0·08	0·02	—
D_2 15/4	—	1·14	1·07	0·94	1·07	0·47	0·59	0·33	0·28	0·12	0·03	—
D_3 30/4	—	—	1·34	1·15	1·41	0·59	0·75	0·46	0·28	0·08	0·02	—
D_4 15/5	—	—	—	1·59	1·19	1·13	0·70	0·51	0·40	0·23	0·05	0·03
D_5 31/5	—	—	—	—	1·57	1·35	1·15	0·64	0·51	0·25	0·07	0·01

It will be observed that the relative growth rate increased almost progressively with the delay in the sowing time of the crop.

The impact of nitrogen on the general growth and development of the cotton crop was studied by Negi and Kanwar Singh (1956a) at Abohar, Hansi and Jullundur over a period of five years, viz., 1952-56. Their data are presented in Table 14.

The data show that the height of the plant, number of internodes, internodal length and dry weight per plant increased progressively as the dose of nitrogen increased from 0 to 125 lb. per acre. However, the fruiting efficiency showed a negative correlation with the dose of nitrogen. This shows that even though the yield of *kapas* goes up with application of higher doses of nitrogen, the increase in yield is not commensurate with increment in dry weight of the plant. Therefore, some way has to be found by which the dose of nitrogen applied to the plant is made more effective for increasing its fruiting efficiency rather than the vegetative growth.

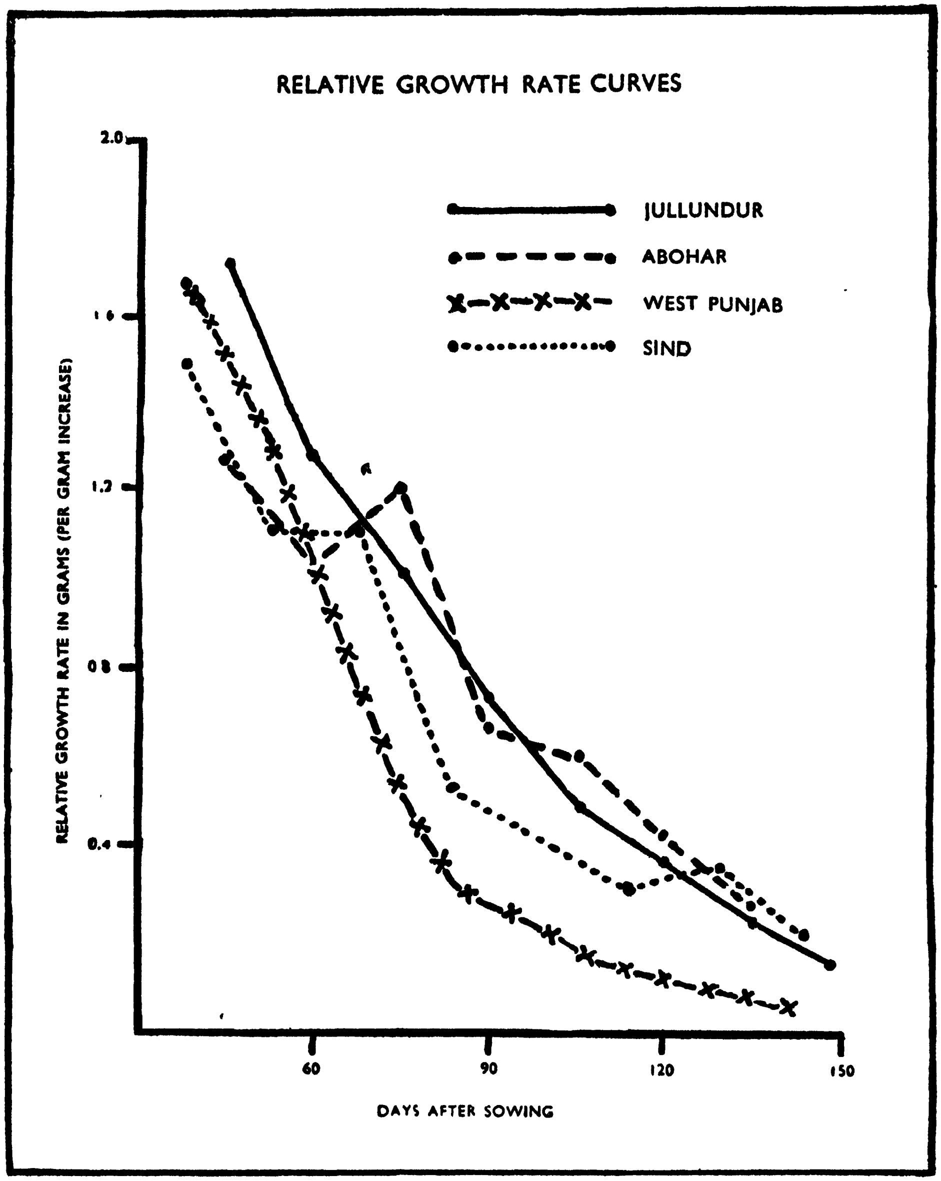


Fig. 8. Relative Growth Rate Curves

TABLE 14. EFFECT OF NITROGEN ON GROWTH OF COTTON PLANT

Place	Nitrogen doses (lb. per acre)	Final height (cm.)	Internode (nos.)	Internodal length (cm.)	Dry weight per plant (gms.)	Yield per plant (gms.)	Fruiting efficiency
Abohar	0	105	35·1	3·00	98	34·2	34·9
	25	123	37·9	3·29	139	53·0	38·1
	50	126	38·2	3·30	186	57·0	30·7
	75	134	39·3	3·41	181	60·2	33·2
	100	139	40·2	3·44	243	66·7	27·4
	125	144	41·0	3·52	276	69·3	25·1
Hansi	0	80	31·5	2·55	75	24·4	32·5
	25	93	32·9	2·85	108	30·6	28·3
	50	98	33·8	2·90	127	37·0	29·1
	75	109	35·1	3·10	161	43·1	26·7
	100	115	36·4	3·16	189	48·6	25·7
	125	122	36·9	3·28	192	51·5	26·8
Jullundur	0	122	39·1	3·12	145	41·3	28·5
	25	129	39·3	3·28	157	41·2	26·2
	50	138	40·3	3·38	191	45·3	23·7
	75	140	41·3	3·39	207	45·3	21·9
	100	143	41·7	3·43	196	47·7	24·3
	125	147	42·7	3·42	197	52·0	26·4

FRUITING PHASE

Formation of Squares. The initiation of the fruiting phase is determined by the number of days taken after sowing to produce the first visible fruiting bud or the number of node on the main stem giving rise to first fruiting branch. In West Punjab, the budding started 1½ to 2½ months after sowing, depending on the variety grown. According to Iqbal Singh, the overall bud initiation period, irrespective of variety, was 39.3 days at Jullundur and 42.9 days at Abohar. However, there were marked varietal differences. At both places the initiation of flower buds occurred 34-38 days after sowing in early group of American varieties and 54-58 days in L.S.S., a late-maturing type. The behaviour of 231R (*desi*) (Plate I-page 84) was different; the inception of flower buds started 44 days after sowing at Jullundur and after 59 days at Abohar. The effect of sowing date on this character gave erratic and irregular trends.

The first fruiting branch arose on 8.7th, 17.5th and 15.1th nodes in early Americans, L.S.S. and 231R, respectively, but this phase of development was markedly modified by change in sowing time. With the advance in sowing date, the initiation of flower bud occurred at a higher node in all the varieties and at both places (Table 15).

The square or bud maturation period, i.e., the number of days from the appearance of square of floral bud to the time of its blossoming under Lyallpur (West Punjab, Pakistan) conditions was 29 days for Mollisoni (*desi*) and 30.6 to 35.5 days for different varieties of American cotton (Afzal, 1949).

TABLE 15. FIRST FRUITING NODE UNDER DIFFERENT DATES OF SOWING

Place	Variety	Date of sowing					Mean
		D_1 31/3	D_2 15/4	D_3 31/4	D_4 15/5	D_5 30/5	
Jullundur	Early Americans	6·6	7·1	8·0	9·6	11·2	8·5
	L.S.S.	10·5	9·1	23·9	26·0	23·9	18·6
	231R	10·5	10·3	16·7	16·6	16·3	14·1
Abohar	Early Americans	7·2	7·8	8·3	9·0	12·1	8·8
	L.S.S.	11·3	14·8	16·1	15·1	22·5	16·0
	231R	11·1	14·2	17·6	18·3	18·9	16·0
	Mean	9·5	10·5	15·1	15·8	17·5	

According to Iqbal Singh, the square period was 30.5, 33.1 and 31.1 days at Jullundur and 23.3, 26.8 and 23.6 days at Abohar for early Americans, L.S.S. and 231R, respectively. Obviously the square period is longer at Jullundur by about 7 days, and the variety L.S.S. takes 2-3 days more than the other two groups to mature its buds at both the places.

The bud maturation period was observed to increase considerably for the squares that appeared later with the advance of the season, as shown in Table 16.

TABLE 16. SQUARE PERIOD AS INFLUENCED BY TIME OF INITIATION

Place	Variety	Square period for bud initiated on			
		10/6	1/8	15/8	25/8
Jullundur	Early Americans	22·4	27·0	30·5	33·9
	L.S.S.	24·6	29·5	31·8	36·2
	231R	21·2	26·4	30·7	36·1
Abohar	Early Americans	18·3	21·0	23·4	25·5
	L.S.S.	21·8	24·7	26·6	29·7
	231R	17·6	20·5	23·6	27·0
	Mean	21·0	24·8	27·8	31·4

It was observed that the sowing time did not have any influence on the square period.

Flowering. One notable difference between the cottons of West Punjab (Pakistan) and those of the Punjab (India) is that whereas in the former, the flowering after having once started in the beginning of August, remains continuous up to the middle of November, under the conditions obtaining in the Punjab (India) the flowering curve is distinctly bimodal (Fig. 9). The first flowering phase generally starts about eight weeks after the sowing date of the crop and attains a peak in the third week of June, thereafter the monsoon

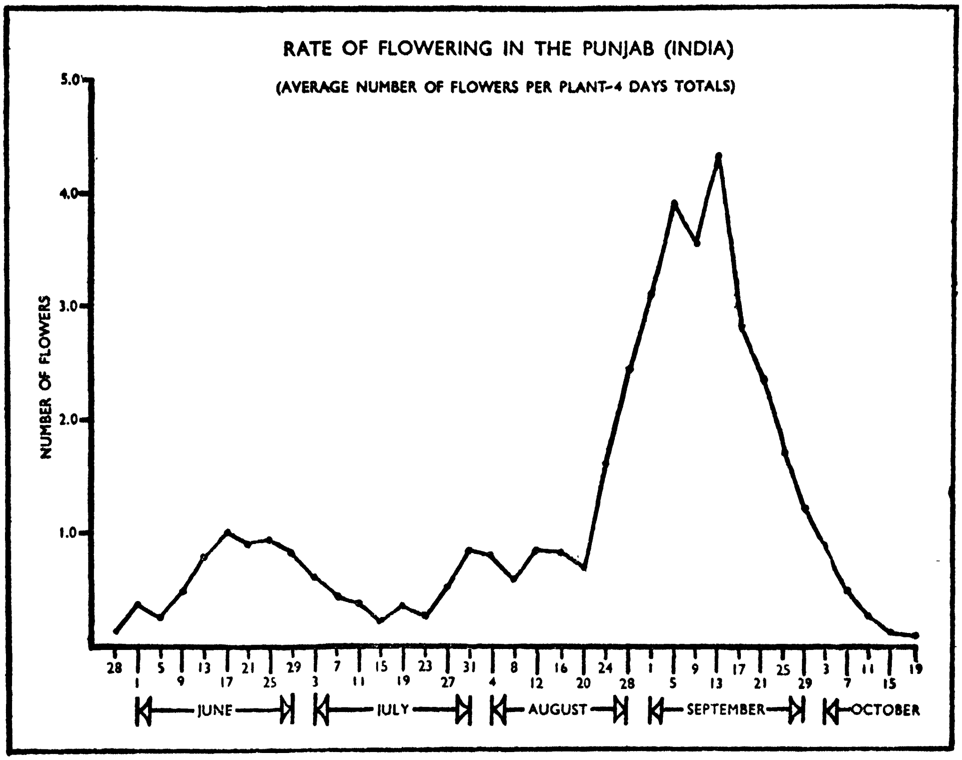


Fig. 9. Rate of Flowering in the Punjab (India)

rains start and the first flowering phase comes to an end, the plant again entering the vegetative phase. The effective flowering starts from the beginning of August and attains the highest peak by the middle of September. By about the first week of October, the flowering curve begins to taper off and in the following fortnight only stray flowering takes place.

The average number of flowers appearing in each of the two phases referred to above was determined in early and late varieties of American cotton and the data are given in Table 17.

Table 17. Number of Flowers Produced per Plant in Two Phases

Variety	Phase I	Phase II	Total
Early Americans	6·18	45·28	51·46
231R	4·01	37·44	41·45
L.S.S.	2·87	43·49	46·36

It will be observed that about 12 and 10 per cent. of the total number of flowers appeared in the first flowering phase in the early American varieties and the *desi* variety, 231R, respectively, whereas in L.S.S., a late American cotton, the magnitude of this flowering was only six per cent. The flowers of the first phase are usually shed, but occasionally they form bolls, which are sub-normal in size, contain a smaller number of seeds, have a low ginning percentage and are defective in opening. Some technological data collected on the produce of this phase are given in Table 18.

TABLE 18. TECHNOLOGICAL PROPERTIES OF LINT FROM BOLLS OF FIRST AND SECOND FLOWERING PHASES

Variety	Bolls of first phase			Bolls of second phase		
	Mean fibre length (inches)	Mean fibre weight per inch (× 10^{-6} oz.)	Maturity percentage	Mean fibre length (inches)	Mean fibre weight per inch (× 10^{-6} oz.)	Maturity percentage
216F	0·82	0·137	62-13-25	0·98	0·136	62-17-21
320F	0·82	0·140	70-12-18	0·95	0·138	65-13-22
Mean	0·82	0·138	66-12-22	0·97	0·137	63-15-22

It will be observed that the staple length was much shorter in the lint from bolls of the early phase, though maturity of lint and fibre weight compared well with that recorded in the lint from normal flowering phase. Nevertheless it is to be concluded that the flowering which takes place in the first phase does not contribute much to the ultimate *kapas* yield that is obtained. The occurrence of the first flowering phase is, therefore, to be regarded as an unnecessary drain on the plant.

With a view to seeing how far a unimodal flowering curve could be obtained, the effect of sowing dates extending from 31st March to 30th May at fifteen days interval was studied in a replicated experiment. The results are presented by graph (Fig. 10), from which it will be observed that, whereas in the first three sowing dates multimodal curves were obtained, they very nearly became unimodal in the last two sowing dates, viz., on 15th May and 30th May. Thus from the point of view of the energy of the plant expended in coming to flowering phase, the sowing on these two dates would seem justified for adoption, but this will have to be considered in relation to other factors, like the degree of the jassid attack and the ultimate yield of seed cotton. It is noteworthy in this connection that the average number of flowers produced per plant decreased progressively from 60.4 to 48.8 as the sowing date advanced from 31st March to 31st May.

The behaviour of the cotton plant in flowering activity under different dates of sowing in combination with varying doses of nitrogen and different spacings was studied by Gursham Singh *et al.* (1958) at Rauni Farm, Patiala. The sowings were done on three different dates, 20th April, 10th May and 1st June, of which the first two are considered to be normal. Delay in sowing brought about a little delay, but not very appreciable, in the onset of flowers.

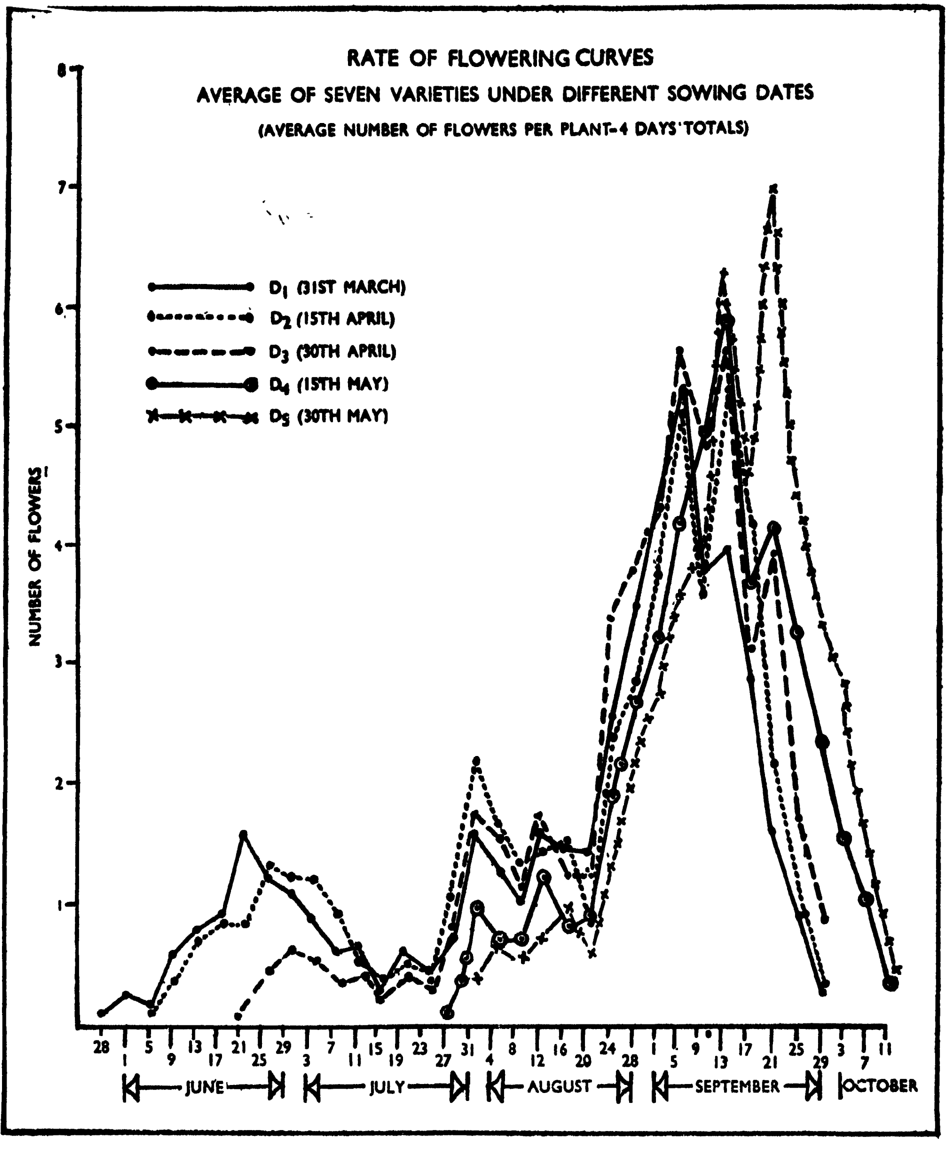


Fig. 10. Rate of Flowering Curves

The peak flowering period was reached almost at the same time in all the sowings. The end of the flowering phase was a little more prolonged in the late sowing. The application of nitrogen did not cause delay in the onset of flowering, but increased the rate of flowering in the later part of the second or major flowering phase, i.e., during September. The total number of flowers produced increased progressively with higher doses of nitrogen as well as with closer spacing.

Boll Formation. The boll maturation period has been studied in *desi* as well as American varieties at two locations, namely, Jullundur and Abohar. The data are presented in Table 19.

TABLE 19. BOLL MATURATION PERIOD IN DAYS FOR DIFFERENT VARIETIES

Place	Year	Early Americans	L.S.S.	231R	Mean
Jullundur	1950	50·8	62·2	44·4	52·5
	1951	42·2	54·2	35·1	43·8
Abohar	1950	37·2	42·8	35·3	38·3
	1951	34·8	41·2	33·3	36·4
	Mean	41·2	49·9	37·0	

It will be observed that the number of days taken from a flower to an open boll varied both with the variety and the location. This observation is in accord with that of Afzal (1949) at Lyallpur in West Punjab. It was also observed that the boll maturation period was lower in the case of early formed flowers and increased progressively as the season advanced. Table 20 gives the data recorded on this aspect.

TABLE 20. BOLL MATURATION PERIOD

Season 1950		Season 1951	
Date of tagging	Boll period (days)	Date of tagging	Boll period (days)
25/8	39·9	27/7	34·1
10/9	43·1	10/8	36·2
25/9	50·1	25/8	39·4
		9/9	42·4

The date of sowing also seemed to have some influence on the boll maturation period. The data given in Table 21 shows that it tended to decrease with advance in sowing time, though the differences observed were not spectacular.

TABLE 21. BOLL MATURATION PERIOD (DAYS) UNDER DIFFERENT DATES OF SOWINGS

Place	Year	D_1 31/3	D_2 15/4	D_3 30/4	D_4 15/5	D_5 30/5
Jullundur	1950	51·8	53·5	53·5	50·7	48·8
	1951	43·5	44·6	43·1	41·9	41·1
Abohar	1950	38·4	38·1	38·8	36·3	36·3
	1951	35·9	36·0	36·4	34·6	34·4
	Mean	42·4	43·1	42·9	40·9	40·2

As also noted by Afzal (1949) in West Punjab, the varieties of American cotton having a lower maturation period for squares have a lower maturation period for bolls also. The *desi* varieties, however, have invariably a lower maturation period for bolls as compared to the American varieties. Data on this aspect are presented in Table 22.

TABLE 22. AVERAGE MATURATION PERIOD OF BUDS AND BOLLS IN EARLY AND LATE AMERICAN VARIETIES

Variety	Average maturation period of squares (days)	Average maturation period of bolls (days)
Early Americans	26·9	41·2
L.S.S. (late variety)	30·0	49·9
231R (*desi*)	27·3	37·0

The effect of the application of nitrogen on the boll number and boll weight has been reported by Negi and Kanwar Singh (1956a) (Table 23).

TABLE 23. EFFECT OF NITROGEN ON BOLL NUMBER AND WEIGHT

Place	Nitrogen doses (lb. per acre)	Number of bolls per plant	Weight of seed cotton per boll (gms.)	Earliness index
Abohar	0	16·5	2·07	0·73
	25	24·0	2·21	0·72
	50	24·8	2·30	0·71
	75	25·0	2·41	0·70
	100	27·8	2·40	0·69
	125	27·6	2·51	0·67
Hansi	0	9·6	2·54	0·75
	25	11·5	2·66	0·77
	50	13·3	2·78	0·75
	75	14·7	2·93	0·75
	100	16·1	3·02	0·73
	125	17·4	2·96	0·71
Jullundur	0	18·1	2·28	0·85
	25	18·4	2·24	0·83
	50	19·6	2·31	0·81
	75	20·2	2·27	0·78
	100	20·4	2·34	0·78
	125	22·8	2·28	0·77

It will be observed that both the number of bolls per plant and the weight of seed cotton per boll increased progressively with the increment in the fertilizer dose from 0 to 125 lb. nitrogen per acre. This result was confirmed by Gursham Singh *et al.* (1958). These authors also found that the number of bolls increased with wider spacing.

The earliness index worked out in each case revealed that this character had a negative correlation with fertilizer dose.

Square and Boll Shedding. The importance of bud shedding has long been realised and various causes have been ascribed to this phenomenon. At Lyallpur (West Punjab) in the American cotton variety, 4F, it varied from 17.80 to 74.52 per cent. in different years; the fluctuations were attributed to the attack of bollworm (*Earias sp.*) (Afzal, 1949). The work of Iqbal Singh in Punjab (India) has shown that setting percentage of buds into flowers is a varietal character and is considerably affected by the sowing date and the conditions obtained at different places as is evident from the data presented in Table 24.

TABLE 24. SETTING PERCENTAGE OF BUDS INTO FLOWERS

Place	Variety	D_1 31/3	D_2 15/4	D_3 30/4	D_4 15/5	D_5 30/5	Mean
Jullundur	Early Americans	45·6	46·4	54·5	59·7	62·3	53·7
	L.S.S.	39·1	35·7	44·0	52·0	57·5	45·6
	231R	51·7	47·0	49·0	49·6	54·3	50·3
Abohar	Early Americans	43·6	47·1	51·8	53·0	53·3	49·8
	L.S.S.	51·3	56·0	67·0	65·1	63·5	60·6
	231R	39·6	42·5	44·5	42·0	43·3	42·3
	Mean	45·1	45·8	51·8	53·6	55·7	50·4

The setting percentage improved gradually with advance in sowing time. It was lowest for L.S.S. at Jullundur and highest at Abohar. For 231R, it was just the reverse. The behaviour of varieties of the early American group, however, was steady at both the places. The setting percentage of buds into flowers is only 50 per cent. (Table 24) and flowers into bolls about 40 per cent. (Table 26). Obviously 80 per cent. of the reproductive forms are shed, which is a great drain on the plant. The application of nitrogen is known to increase the yield of cotton but whether this is due to improvement in setting percentage of the fruiting forms or other causes was investigated by Negi and Kanwar Singh (1956a) and their data on this aspect in a consolidated form are given in Table 25.

TABLE 25. EFFECT OF NITROGEN ON SETTING PERCENTAGE OF BOLLS

Nitrogen doses (lb. per acre)	Yield per plant (gms.)	Total fruiting points per plant	Number of bolls matured	Setting percentage
0	33·3	69·7	14·7	21·1
25	41·6	88·3	18·0	20·4
50	46·4	93·3	19·2	20·5
75	49·5	106·3	20·0	18·8
100	54·3	110·0	21·4	19·4
125	57·6	115·7	22·6	19·5

The setting percentage was not improved by nitrogen, rather it created a tendency towards more shedding in higher doses; the increase in yield was merely due to the formation of a larger number of fruiting points.

Iqbal Singh's data revealed that the setting percentage of flowers into bolls was similar in *desi* and American varieties (Table 26). Afzal (1949) came to the same conclusion from the data collected at Lyallpur (West Pakistan) that the relative shedding percentage is, on the whole, equal in American and *desi* cottons. The former also showed that the setting percentage of bolls was different under conditions obtained at different places (Table 26). In L.S.S., it was higher at Abohar than at Jullundur, with 231R, on the other hand, it was the reverse.

TABLE 26. SETTING PERCENTAGE OF FLOWERS INTO BOLLS

Locality	Year	Early Americans	L.S.S.	231R
Jullundur	1950	34·9	30·5	33·6
	1951	46·8	46·0	52·7
Abohar	1950	35·3	41·6	27·2
	1951	42·5	47·5	42·8
	Mean	39·9	41·4	39·1

The setting percentage of flowers into bolls was found to improve considerably when the sowing time was shifted, as is evident from the data given in Table 27.

TABLE 27. SETTING PERCENTAGE OF FLOWERS INTO BOLLS UNDER DIFFERENT SOWING DATES

Locality	Year	D_1 31/3	D_2 15/4	D_3 30/4	D_4 15/5	D_5 30/5
Jullundur	1950	24·7	26·3	28·5	44·4	46·4
	1951	41·7	41·3	48·4	50·9	55·9
Abohar	1950	32·5	33·5	32·9	36·9	41·1
	1951	36·5	40·3	43·3	45·2	50·7
	Mean	33·9	35·4	38·3	44·4	48·5

However, Gursham Singh *et al.* (1958) working at Rauni Farm, Patiala, found that neither the application of nitrogen nor change in sowing date materially affected the setting percentage of bolls.

There is evidence to show that the setting percentage is improved by hormones. Sucha Singh and Greulack (1949) obtained increased success percentage of bolls by the application of chemical hormones, naphthalene acetic acid and napthalene acetamide. Dastur and Ved Parkash (1954) obtained significantly increased yields in *desi* cotton by the application of α-naphthyl acetic acid at 10 p.p.m. In the Northern Region the work was initiated by Negi and Avtar Singh (1956c), at Hansi, where it was found that P.A. 216F responded to the treatment of α-naphthalene acetic acid, by giving a higher number of bolls per plant and increased yield in the third picking, covering the period of 50 to 116 days after the hormone treatment (Table 28). As the square plus boll period in the Punjab for early-maturing varieties is 76 days, it appears logical to presume that the square initiating on the day of treatment and afterwards benefited from the application of hormone but not those squares and bolls, which were already formed.

TABLE 28. NUMBER OF BOLLS PER PLANT AND YIELD OF *Kapas* BY ALPHA-NAPHTHALENE ACETIC ACID

Treatment	1952 Number of bolls per plant			*Kapas* yield (lb. per acre)	1953 *Kapas* yield per acre		
	First three pickings	Last picking	Total		First two pickings	Third picking	Total
5 p.p.m.	—	—	—	—	1,281	174	1,455
10 „	15·10	3·17	18·27	1,294	1,332	214	1,546
20 „	14·38	1·77	16·15	1,128	—	—	—
Control	14·10	1·45	15·55	1,193	1,250	165	1.415
C.D. 5% I	N.S.	0·35	—	N.S.	—	34	—

The data in Table 28 indicate that out of the three concentrations tried 10 p.p.m. was the best. In Uttar Pradesh the concentration of 5 p.p.m. of α-naphthalene acetic acid was found to be more beneficial than 10 p.p.m., both for *desi* (35/1) and American (216F) cotton. At Raya for 216F an increased *kapas* yield of 52 lb. per acre and 194 lb. and 102 lb. for 35/1 at Muzzaffarnagar and Meerut were obtained. At Nasirpur (Punjab), the American cotton variety 320F did not show any response in yield, boll weight or height of the main stem to 10 p.p.m. of α-naphthalene acetic acid, but the *desi* cotton variety 231R gave a significantly higher yield over water-sprayed and control treatments, the increase in yield being 108 lb. per acre.

The effect of hormones on the setting percentage was studied by Malkani and Asana (1958). They tried several hormones, namely, para-chlorophenoxy acetic acid (PCPA); β-naphthoxy acetic acid (NOA); 2,3,5, tri-iodo-benzoic acid (TIBA); α-naphthyl acetic acid (NAA); β-indolyl acetic acid (IAA) and indolyl butryic acid (IBA) in several concentrations, with and without a wetting agent on P.A. 216F during 1955-57. Of these the hormones NAA, IBA, and IAA were found more effective in a concentration of 40 p.p.m. without addition of a wetting agent and the hormone NOA in a concentration of 5 p.p.m. with a wetting agent proved to be equally effective. The best time for applying the treatment was 35 days after sowing. The improvement in boll setting percentage and yield by the most effective hormones under field-scale trials was as shown in Table 29.

TABLE 29. INFLUENCE OF GROWTH REGULATING HORMONES ON YIELD AND BOLL SETTING PERCENTAGE

Character	NAA	IAA	NOA	Control	C.D. 5 % ± control *vs* treatment mean
Number of flowers per plant	98·1	102·4	101·2	114·4	5·48
Number of bolls per plant	32·7	35·1	33·5	29·0	N.S.
Setting percentage of bolls	33·4	34·3	32·9	25·4	2·87
Weight of seed cotton per plant	89·4	91·3	88·3	71·4	12·52
Kapas yield (mds. per acre)	22·41	21·68	22·29	17·75	2·55

The use of NAA and NOA was more economical than others because their cost was only Rs. 6 to Rs. 7 per acre while the increase in *kapas* yield brought about by them was of the order of 4-5 maunds, with a value, at very conservative rates, of over Rs. 100.

COTTON CULTIVATION

In India hardly nine per cent. of the cotton crop is irrigated. As the major portion of irrigated crop, i.e., seven per cent. is grown in the Northern *hirsutum-arboreum* Region, the cultural practices followed here are quite different from those of other regions. The practices in vogue, and their merits as became apparent from years of experimentation are briefly outlined in the following lines :

ROTATION

The cotton crop in the Northern Region mostly follows wheat, but occasionally it is fitted in rotation with gram, *berseem* or sugarcane. In some cases, it is also sown after winter fallow.

In a study to find out the best rotation for obtaining a high yield of cotton, the following four rotations, each having a three-year course, were studied at the Agricultural Research Station, Hansi, from 1949-53.

1. Wheat-*berseem*-cotton (farm yard manure applied to *berseem* at 5 tons per acre)
2. Wheat-*guara* (fodder)-cotton
3. Wheat-cotton-sugarcane (farm yard manure applied to sugarcane at 10 tons per acre)
4. Wheat-*guara* (green manure)-cotton.

The yields of cotton obtained in the above rotations are given in Table 30.

The data presented in Table 30 show that the highest yield of cotton was realised when it followed the green manure crop of *guara* combined with *rabi* fallow. The surprising result is that cotton following *berseem* crop gave the lowest yield, while in Egypt and West Punjab (Pakistan) the *berseem*-cotton

TABLE 30. YIELD OF *Kapas* IN DIFFERENT ROTATIONS

Rotation number	Yield of *kapas* (maunds per acre)				
	1949	1950	1952	1953	Average
I	8·97	13·85	15·45	13·49	12·94
II	9·71	17·80	13·58	16·52	14·40
III	9·19	16·68	15·95	15·26	14·27
IV	10·52	17·53	18·64	22·16	17·21

rotation has been found to be ideal. This discrepancy can be explained on the basis that the optimum time for the sowing of cotton crop in the Punjab (India) lies between middle of April and middle of May, by which time, the *berseem* crop is still green. By the time this fodder crop is harvested for the last cut, it becomes too late to sow cotton. It is obvious that if advantage of this legume for enhancing cotton yields is to be taken, its last one or two cuttings shall have to be sacrificed.

A more comprehensive set of rotational experiments was laid out recently at three locations namely, Jullundur, Hansi and Abohar in the Punjab. In these experiments, the following five rotations, each of a three-year duration, were included :

Wheat-wheat-cotton (r_1)
Wheat-gram-cotton (r_2)
Wheat-*berseem*-cotton (r_3)
Wheat-*guara*-cotton (r_4)
Wheat-fallow-cotton (r_5)

The cotton yields obtained in the above rotations are given in Table 31, as reported by Negi and Kanwar Singh (1956b).

TABLE 31. EFFECT ON YIELD OF COTTON BY PREVIOUS ROTATION CROP

Rotation	Yield of *kapas* (maunds per acre)				Percentage increase over control
	Abohar	Jullundur	Hansi	Average	
(r_1) Wheat-wheat-cotton	14·7	14·0	8·0	12·2	—
(r_2) Wheat-gram-cotton	16·8	16·5	11·4	14·8	21
(r_3) Wheat-*berseem*-cotton	17·6	17·9	9·3	14·9	22
(r_4) Wheat-*guara* (grain)-cotton	21·5	18·2	11·1	16·9	38
(r_5) Wheat-fallow-cotton	19·8	19·0	13·8	17·5	43

The results in Table 31 show that a cotton crop following gram, *berseem*, *guara* (grain) or fallow gave higher yield than that rotated with wheat. It is also obvious that the highest yield was realised from the crop which was raised after two successive fallows in the *kharif* and *rabi* seasons.

The economics of the above rotations, omitting the first wheat crop which was common to all, has been worked out and the results are presented in Table 32.

TABLE 32. COMPARATIVE CASH RETURNS FROM DIFFERENT ROTATIONS

Crop	Yield of rotation crop (mds.)		Value of intermediate crop (rupees)		Value of cotton (rupees)	Total value (rupees)
	Grain	Straw	Grain	Straw		
Wheat-cotton	18·6	44·0	260	88	366	714
Gram-cotton	14·9	30·5	149	31	444	624
Berseem-cotton	380 (Green fodder)	—	285	—	447	732
Guara-cotton	10·9	35·6	109	36	507	652
Fallow-cotton	—	—	—	—	525	525

It will be observed that, while the highest yield of cotton was obtained in wheat-fallow-cotton rotation, the gross income from this rotation was lower than from all the other four rotations experimented with. The highest income was realised in the *berseem*-cotton rotation. Therefore, if adequate irrigation water is available to meet the excessive water requirements of the *berseem* crop, the cotton growers could adopt this rotation with advantage. The wheat-cotton rotation ranked next as regards gross income, but, because of the exhaustive nature of this rotation, its large-scale adoption could not be advocated. The other two rotations, in which cotton followed gram or *guara* (grain), are also ideal for adoption, despite their slightly lower cash return per acre. The occurrence of a legume in these rotations will be very beneficial for building up soil-fertility and a progressive increase in cotton yield could be expected over a period.

As a result of the introduction of the early-ripening *hirsutum* varieties in the south-eastern parts of the Punjab (India), cotton growers have found it possible to adopt a cropping intensity of 200 per cent. In the new rotations, which are now becoming increasingly popular, wheat, gram or peas are sown immediately after the removal of the cotton crop in October. While the fitting of wheat in the rotation is not a very happy development, because of its exhaustive nature, the sowing of gram or peas after cotton is a welcome practice which needs to be encouraged.

PRE-SOWING CULTIVATION

The purpose of cultivation is to pulverize the soil and obtain proper tilth, which is conducive to good germination and growth. It also helps in suppression of weeds, preservation of soil moisture and promotes aeration.

The amount of pre-sowing cultivation depends upon the time available between the harvesting of the previous crop and the planting of cotton. When cotton follows wheat, gram or *berseem* the interval is too short for pre-sowing cultivation. The thrashing of the *rabi* crop also clashes with the sowing time of cotton. Many a time the non-availability of irrigation water in the early *kharif* season also imposes a limitation on the pre-sowing cultivation. The land is consequently given only one or two ploughings with a *desi* plough, irrigated thereafter and sown with cotton. The inadequacy of the preparatory tillage has, therefore, to be made good by repeated interculture in the standing crop. When cotton follows *guara* or any other *kharif* crop, which permits winter fallow, the cultivation is done during the winter months and consists of four ploughings with a *desi* plough. This cultivation helps a good deal in obtaining proper tilth, which is conducive to a good yield of the crop.

SOWING TIME

The sowing time of cotton is largely determined by two factors—soil temperature and seasonal conditions. Afzal (1949) found that a satisfactory germination of cotton seed cannot take place below 18°C. and, therefore, recommended that sowing should not be done before 15th March as, in the Punjab, the soil temperature at 5 and 30 cm. depth ranged between 12° and 18°C. during February and early March and began to rise thereafter.

Exhaustive sowing date experiments to determine the optimal sowing time were conducted in the pre-partition Punjab, since 1926, by Afzal (1949) and Dastur (1944). Both found that the best time for sowing American cotton in the Punjab was the middle of May to the middle of June and for *desi* cotton from the middle of May to the beginning of July. These results, however, have no application for Indian Punjab, where climatic and other conditions are appreciably different from those in West Pakistan.

After Partition, sowing date experiments were conducted in the erstwhile Pepsu State and it was found that the optimum planting time of cotton lay between 1st April and 15th May for the Patiala tract and between the beginning of April and the end of May for the Bhatinda tract (Gursham Singh and Atwal, 1955).

A number of sowing date experiments have also been carried out on American varieties, since 1953, at Abohar, Jullundur and Hansi in the Punjab (India). The effect of the sowing date on the yield of *kapas*, as reported by Gursham Singh and Kanwar Singh (1957), is shown in Table 33.

TABLE 33. EFFECT OF SOWING DATE ON YIELD OF COTTON

Place of trial	Average yield of *kapas* (maunds per acre)		
	End April	Mid May	Early June
Abohar	17·2	16·3	15·3
Jullundur	15·4	13·8	9·8
Hansi	14·2	13·2	10·3
Average	15·6	14·4	11·8

The data reveal that early sowings were conducive to a high yield at all the three centres. This was contrary to the findings of Dastur (1944) and Afzal (1949) who advocated late sowings of American cotton in the canal colony areas of West Pakistan.

Apart from realising a higher yield, the following other advantages also accrue from early sowings:

1. In North-western and South-eastern zones, it has been observed that, because of the incidence of pink bollworm, which appears in the month of October, the larger the number of green bolls on the plant after October, the greater their chances of getting infested with this pest. In early sowings, the crop matures before the pest appears and the greater portion of the crop, therefore, escapes damage.
2. An early-sown crop establishes itself well before the onset of monsoon rains in July and, therefore, suffers less from the excess of moisture and the inroads of weeds.
3. A late-sown crop, particularly the one sown after the first or second week of May, is exposed to the attack of field cricket (*Gryllus viator*) and *toka* (*Chrotogonus trachypterus*). The germinating cotton fields are particularly devastated on a wide scale by these pests in the South-eastern zone in certain years. The early-sown crop, however, escapes their damage.
4. The late-sown crop, being still soft and succulent, at the time when the jassid attack commences, suffers from it badly, whereas the early-sown crop is much less affected.
5. In South-eastern zone, it is the practice to take a *rabi* crop immediately after the harvest of cotton from the same field. It is possible to follow this practice conveniently if the cotton crop is sown and harvested early.
6. The early-sown crop has at its disposal a longer period of flowering and boll formation. This raises the yield.

Sowing date experiments have also been carried out by Dabral (1955) in Uttar Pradesh on *desi* cotton. His findings showed that the sowings done during the month of May were conducive to a high yield of the crop.

Sowing Date and Spacings. It has generally been observed that late-sown plants do not put in normal vegetative growth, remain comparatively smaller in size, give out a lesser number of monopodial branches and bear fewer bolls. Experiments have been carried out to find out whether the deficiency in productivity caused by late sowing can be made good by increasing the number of plants. Afzal (1949) found, at Lyallpur, that close spacing was necessary, when the sowing was delayed beyond the optimum time. Dastur (1944) found that no advantage accrued in early sowings either in boll number or in the yield as a result of close spacing, while late sowing definitely profited by it. He worked out a schedule giving an idea of how the seed rate should be adjusted to the advance in sowing time to get suitable spacing. This is reproduced in Table 34.

TABLE 34. SCHEDULE OF SEED RATE AND SPACING WITH ADVANCE IN SOWING TIME

Date of sowing	Seed rate to be used per acre (seers)	Distance to be kept between rows (feet)	Distance to be kept between plants (feet)
25th May to 31st May	7- 9	2½	1½
1st June to 7th June	8-10	2½	1¼
8th June to 15th June	10-12	2	1¼
16th June to 23rd June	12-14	2	1
24th June to 30th June	14-16	1½	¾

Experiments conducted by Gursham Singh and Atwal (1955) in North-eastern and South-western zones confirmed that the yield differences between closer and wider spacings were more marked in late sowings.

The results of the experiments conducted under the "Scheme for Manurial Trials on Cotton in the Punjab" (Gursham Singh and Kanwar Singh, 1957), in the three important cotton-growing zones of the Punjab also bear out this point and are given in Table 35.

TABLE 35. YIELD OF COTTON AS INFLUENCED BY SOWING DATES AND SPACINGS

Place of trial and zone	Average yield of *kapas* (maunds per acre)								
	End April			Mid May			Early June		
	S_1 (2×1)	S_2 (2×1½)	S_3 (2×2)	S_1 (2×1)	S_2 (2×1½)	S_3 (2×2)	S_1 (2×1)	S_2 (2×1½)	S_3 (2×2)
Abohar (South-western zone)	17·8	17·8	16·5	17·4	16·1	17·7	16·6	14·3	13·6
Jullundur (North-western zone)	15·4	15·1	15·4	15·7	13·6	12·5	10·4	10·4	8·7
Hansi (South-eastern zone)	13·9	14·5	13·8	14·6	14·1	11·3	10·9	10·6	9·4
Mean	15·7	15·8	15·2	15·9	14·6	13·8	12·6	11·7	10·6
Increase over S_3	+0·5	+0·6	—	+2·1	+0·8	—	+2·0	+1·1	—

In these experiments, the distance between rows was kept constant and the spacing between plants within a row was varied, so that a simple recommendation could be made to the cotton growers on this aspect. The results reveal that, in timely as well as late sowings, the distance between rows could be kept at two feet, but when late sowing was practised, the distance between plants had to be reduced to one foot. By this adjustment in spacing, the crop sown in mid-May can give as much yield of *kapas* as given by the crop sown at the end of April with wider spacing.

Sowing Date and Pests. Dastur (1944), observed that the late-sown crop was very succulent by the time the jassids appear and consequently, it was more severely attacked by the pest than the early-sown crop. It was shown by Afzal and Ghani (1946) that the jassid population was significantly less in the early-sown crop than in the late-sown one. It was also observed that the leaf veins, where the jassids usually lay eggs, were significantly tougher in the early sowings and that the toughness of veins appreciably decreased with an advance in the sowing date. Visual observations made in the Northern Region are in accord with the above findings, and it has generally been noticed that the late-sown crop suffers considerably more from the incidence of jassids. Late sowings have, therefore, to be avoided, if the crop is to be saved from the damage by this pest.

Lal and Singh (1951) made observations on the incidence of leaf roller (*Sylepta derogata* Fabr.) in the crop of Perso-American sown in pre-monsoon and post-monsoon periods. The findings of these authors indicate that the former was attacked by the pest more readily than the latter. These results, however, need further confirmation.

Sowing Date and Lint Characters. The fibre properties of Punjab-American 320F and Punjab-American 216F were studied by Jambunathan (1955) in a sowing date experiment conducted at Jullundur in the Punjab State. The results showed that, in both varieties, the late sowing done in June and July adversely affected the length and maturity of the fibre. In contrast to this, the early sowings done in April and May produced cotton of high quality. It is to be concluded from these results that, by sowing the crop at the optimum time, not only higher yield is obtained but quality also is improved.

PREPARATION OF SEED BED

The seed bed for cotton is prepared by giving about two ploughings after a heavy pre-sowing irrigation. After each ploughing, the land is planked so as to pulverise the soil to as fine a tilth as possible. A fine and mellow seed bed with granules not bigger than 3 mm. in diameter is considered to be the best for the cotton crop, as the fine tilth not only helps good germination of seeds, but is also conducive to the preservation of moisture in the soil for a longer time. Dalip Singh and Nijhawan (1944) found at Lyallpur that 33 per cent. more moisture was present in finely prepared, mulched land than in a cloddy field. Though most farmers in the Northern Region make a good effort to prepare proper seed bed, in some cases the preparation is far from satisfactory. In such fields the stand of the crop remains widely spaced and ultimately a low *kapas* yield is obtained. There is thus considerable scope for educating the farmers in the preparation of a fine seed bed for the cotton crop.

SEED RATE, PREPARATION OF SEED FOR SOWING AND METHOD OF SOWING

The cotton varieties grown in the Northern Region fall into three main categories as far as their seed characters are concerned. The first category includes *desi* cottons, all of which have small, downy seeds. The second category consists of American varieties with semi-naked seed; while the third category, though also of American cotton, has seeds with a thick coating of fuzz. The seed rate which is generally used in each of these three categories of varieties is given in Table 36.

TABLE 36. NORMAL SEED RATE OF DIFFERENT CATEGORIES OF COTTON SEED

Category of seed	Variety of cotton	Recommended seed rate per acre
Small downy seeds	M. 60-A.2, 231R, C.520, 35/1 and Ganganagar 1	5- 6 seers
Semi-naked American	L.S.S. and 320F	6- 8 seers
Fuzzy American	216F and H.14	8-10 seers

Soaking of seeds in water for about four hours in case of *desi* cotton and for about six hours in case of American cotton has become a popular practice with the cotton growers, as this practice improves the gremination of seeds and ensures a good stand of the crop. After the soaking, the seeds are separated from each other by mixing them with fine, dry earth and lapping the seeds gently by hands. Disentangling the seeds in this way, particularly in case of the fuzzy varieties, facilitates a uniform sowing. Delinting of seeds in cotton ginneries is not done on any extensive scale in the Northern Region.

With a view to finding out if the use of graded seed can yield a higher crop, as found by Panse and Khargonkar (1948) and by Ganesan (1950a) in case of some of the *arboreum* cottons, an experiment was laid out at Hansi in the Punjab with Punjab-American 216F. The results showed that, while the use of heavy seeds gives a good start to the crop, its ultimate yield does not improve. It, therefore, appears that while sowing graded seed under rainfed conditions may be a good practice in certain tracts, such a practice under the irrigated conditions of the Northern Region may not prove very useful.

Experiments have also been conducted in the northern tract with some American cottons to find out if treating the seed with Agrosan or Perenox which are good seed disinfectants for anthracnose and angular leaf spot diseases, would be conducive to increasing the yield of the crop. No beneficial results from such treatment were, however, obtained. This is probably due to the fact that the incidence of angular leaf spot and anthracnose in the Northern Region is not very high.

The possibility of freeing the seed from pink bollworm before using it for sowing has also been investigated in the Punjab. The fumigation of seeds with methyl bromide for a period of 24 hours completely got rid of the pest, but the incidence of bollworm in cotton crop raised from fumigated seed was not appreciably decreased. It appears that the secondary infection of bollworm, taking place in the cotton crop of this region, is more serious than the infection carried through the seed used for sowing purposes.

Soaking of seeds in nutrient solutions of ammonium sulphate, ammonium phosphate, potassium nitrate and potassium phosphate has also not been found to be conducive to a higher yield of the crop in the Northern Region, as Bhatt and Patel (1955) found in Bombay State.

Sowing of cotton in the Northern Region was mostly done by the broadcast method some years ago, but lately line sowing is becoming popular on the recommendations of the Agricultural Departments of the region. In the Punjab, a single row, bullock-drawn seed drill has been invented for facilitating line sowing and this drill is becoming very popular with the cotton growers on account of its low cost and the very satisfactory germination of seeds which it gives. In some cases, the crop is sown by dropping the seeds by hand in the furrow behind a plough, but as it is difficult to control the depth of sowing by this method, the germination of seeds is generally not as satisfactory as with a seed drill.

SPACING

The common practice in the Northern Region is to space the rows of American cotton at 3 feet distance and that of *desi* cotton at 2-2½ feet. The spacing experiments conducted at Hansi in the Punjab State with Punjab-American 216F and the *desi* variety, Mollisoni 60-A.2, however, indicate that a spacing of even closer than 2½ feet would be necessary for the best *kapas* yield. The experimental results in support of this conclusion are summarised in Table 37.

TABLE 37. RESULTS OF SPACING EXPERIMENTS AT HANSI

Spacing between rows (feet)	Yield of *kapas* (maunds per acre)			
	M.60-A.2			216F
	1941	1942	1943	1944
1	—	—	15·20	—
1½	—	12·87	15·77	26·57
2	21·34	10·63	16·66	25·55
2½	19·14	8·77	15·56	24·28
3	17·65	8·83	—	22·74
S.E.±	0·403	0·320	0·659	0·495

In another experiment carried out at Abohar, Jullundur and Hansi, the constant distance of two feet between rows was combined with a one-foot, a one and a half-foot and a two-foot spacing between plants of the same row. The results of this experiment are given in Table 38.

TABLE 38. EFFECT OF SPACING BETWEEN PLANTS ON YIELD OF COTTON

Spacing between plants	Yield of *kapas* (maunds per acre)		
	Abohar	Jullundur	Hansi
2' × 1'	17·3	13·8	13·1
2' × 1½'	16·1	13·0	13·1
2' × 2'	15·9	12·2	11·5

It will be observed that the results generally favoured closer spacing. On the whole, it can be concluded that a spacing of 2' x 1' is the optimum distance for adoption in case of the cotton crop of the Northern Region.

With a view to finding out if spacing has any relation to the fertility of soil, Gursham Singh and Atwal (1955) conducted complex experiments, including different spacings and doses of nitrogen, at Faridkot and Rauni Farm (Patiala) and the results obtained are summarised in Table 39.

TABLE 39. RESPONSE OF DIFFERENT SPACINGS TO NITROGEN

Place of trial	Spacings	Yield of *kapas* (maunds per acre)		
		N0	N50	N100
Faridkot	2' × 1¼'	17·7	19·2	20·1
	2½' × 1½'	16·1	19·4	18·6
Rauni Farm	2' × 1¼'	13·0	15·5	15·6
	2½' × 1½'	12·0	14·4	14·9

The above data show that, even under heavy manuring, closer spacing is preferable.

INTERCULTURE

It has been mentioned earlier, that, as a large percentage of the cotton crop in the Northern Region is rotated with wheat and other *rabi* crops, the preparatory tillage given for sowing this crop is rather inadequate. This deficiency has to be made up by repeated interculture. In the initial stages, when the crop is very young, the hoeing of the crop is done with a hand implement called *khurpi*. Hoeing the crop at this stage is considered very important. In fact there is a local saying amongst the cotton growers of the Punjab that if the crop is not hoed when the plants are at the two-leaf stage, then there will not be much seed cotton to pick. At a slightly later stage of growth, hoeing is done with another implement called *kasaula*, in which a triangular blade is attached to a long bamboo handle. At a still later stage of growth, interculture by means of bullocks is done. For this purpose an improved implement, called *triphali* (Fig. 11), devised by the Punjab Department of Agriculture is proving popular with the cotton growers. The use of this implement is possible only if the crop has been sown in lines. In case of the broadcast crop, as well as to some extent in the crop sown in lines, interculture may be done with the help of the country plough. In fact, a large number of cotton growers use the country plough for interculture not only with the object of loosening the soil, but also for carrying out a thinning operation. No doubt the use of the country plough for thinning saves somewhat on labour cost, but it has a definitely adverse effect on the ultimate stand of the crop, as thinning done by this means cannot be very uniform. This practice has, therefore, to be discouraged, if good yields from the cotton crop are to be realised. The last interculture to the cotton crop with the help of the *triphali* or country plough is given in the month of July. After this month, the cotton plants make an excessive growth and it is not possible to do any further interculture.

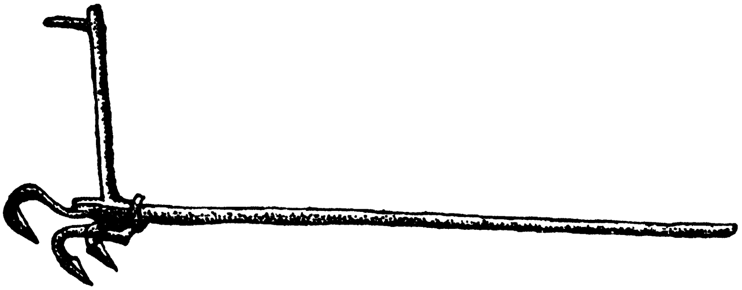


Fig. 11. *Triphali*

Several experiments have been conducted on cotton crops with a view to finding out if the number of hoeings given to the crop has any effect on its yield. They reveal that hoeing is usually more beneficial for suppressing weeds than for improving the soil tilth. When there are no weeds in the cotton crop, frequent interculture is not very advantageous.

IRRIGATION

The irrigation requirements of cotton crops were worked out in the Scheme for Water Requirements of Crops sanctioned by the Indian Council of Agricultural Research at Lyallpur (now in West Pakistan). These studies showed that about 20 acre-inches of water are required to mature a cotton crop successfully (Table 40).

TABLE 40. EFFECT OF QUANTITY OF WATER ON YIELD OF COTTON

Particulars	Year	Acre-inches of water and number of waterings					
		9″ (3)	12″ (4)	15″ (5)	18″ (6)	21″ (7)	24″ (8)
Yield of *kapas* per acre (mds.)	1942	20·2	20·8	21·6	22·6	23·6	23·4
	1943	13·9	15·0	15·7	17·2	19·5	19·5
	Average	17·0	17·9	18·6	19·9	21·5	21·4

It was also found that it was immaterial whether this quantity of water is applied in three or more irrigations (Table 41).

TABLE 41. YIELD OF COTTON AS INFLUENCED BY 20 ACRE-INCHES OF WATER APPLIED IN DIFFERENT NUMBER OF WATERINGS

Particulars	Year	Twenty acre-inches of water applied in					
		3 Irrigations	4 Irrigations	5 Irrigations	6 Irrigations	7 Irrigations	8 Irrigations
Yield of *kapas* per acre (mds.)	1942	14·9	14·7	—	14·8	15·2	14·8
	1943	10·6	10·6	10·6	10·7	11·1	—
	Average	12·7	12·6	—	12·7	13·1	—

What counted was the total quantity of water and not the number of irrigations. Whether these findings are applicable to the cotton crop grown in the Punjab and other parts of the Northern Region has yet to be found out. No well-arranged experiments on these aspects have been carried out. It appears, however, that the irrigation requirements of the cotton crop in the Northern Region may not be as high as was the case at Lyallpur. The reason for this is that most of the cotton-growing areas in this part of the country have an appreciably higher rainfall than Lyallpur. The cotton crop is generally sown in the months of April and May and by the time the monsoon rains start in July, the crop hardly requires one or two irrigations. During the monsoon period, if adequate rain is received, then irrigation may not be necessary. One more irrigation may have to be given to the crop after the cessation of rains in the month of September. The crop in the Northern Region has also a shorter growing period, most of the pickings being over by the end of October, whereas at Lyallpur the crop continued up to the end of December and sometimes even till the first week of January. Thus the cotton crop in the Northern Region is hardly given three to four irrigations (five to six in south-western zone, being arid), whereas in West Pakistan, six to seven irrigations, each three inches deep, were considered to be optimum.

There is a slight difference in the number of irrigations to be given to the crop of American and *desi* cottons. *Desi* cottons by virtue of their longer tap root and greater capacity to withstand drought can do with much less water than the American varieties. However, there is no experimental data as yet to show this conclusively.

Experiments carried out under the Scheme for Cotton Manurial Trials in the Punjab (I.C.C.C., 1956) go to show that, if the cotton crop is manured with nitrogenous fertilizers, there is a higher response to the fertilizer with six irrigations than with five. This result was mostly obtained in the experiments carried out at Abohar. Similar experiments at Hansi and Jullundur, however, did not show any marked difference in this regard.

MANURING

Application of Inorganic Nitrogenous Fertilizers

Optimum Dose of Nitrogen. The soils all over the Northern Region are deficient in nitrogen. Response to the application of nitrogen is, therefore, well marked. With a view to finding out the optimum dose of nitrogen for the cotton crop, experiments were carried out by Negi and Kanwar Singh (1956a) in three distinct cotton zones in the Punjab represented by Abohar, Jullundur and Hansi. The data obtained from these experiments are presented in Table 42.

TABLE 42. RESPONSE MANIFESTED IN *Kapas* YIELD TO GRADED DOSES OF NITROGEN

Place of trial	Doses of nitrogen (lb. per acre)	Mean yield of *kapas* per acre (mds.)	Increase over control (mds.)	Percentage increase in yield	Increase in yield per lb. of nitrogen (lb.)	Net Income (Rs.)
Abohar	0	15·6	—	—	—	—
(South-western	25	20·0	4·4	28·2	14·4	112·50
zone)	50	22·0	6·4	41·0	10·5	153·00
	75	23·2	7·6	48·7	8·3	169·50
	100	24·2	8·6	55·1	7·1	180·00
	125	26·2	10·6	67·9	7·0	220·50
Jullundur	0	13·3	—	—	—	—
(North-western	25	14·9	1·6	12·0	5·2	28·50
zone)	50	15·8	2·5	18·8	4·1	36·00
	75	16·5	3·2	24·1	3·5	37·50
	100	15·9	2·6	19·5	2·1	—
	125	16·1	2·8	21·1	1·8	13·50
Hansi	0	8·5	—	—	—	—
(South-eastern	25	11·1	2·6	30·6	8·5	58·50
zone)	50	13·3	4·8	56·8	7·9	100·00
	75	16·1	7·6	89·4	8·3	169·50
	100	17·5	9·0	100·6	7·4	192·00
	125	19·0	10·5	123·5	6·9	217·50

It will be observed from the data given in the above Table that there was a progressive increase in the mean yield of seed cotton per acre with the increase in the dose of nitrogen from 0 to 125 lb. As regards the economics of manuring, the data show that, whereas at Abohar and Hansi the income per acre went up with increased doses of nitrogen up to 125 lb. per acre, at Jullundur the doses beyond 75 lb. were less remunerative, the 50 lb. dose gave a net income almost equal to the 75 lb. dose.

In the above experiments, the residual effect of nitrogen on the yield of the succeeding wheat crop was studied. The results are given in Table 43.

TABLE 43. RESIDUAL EFFECT OF GRADED DOSES OF NITROGEN ON YIELD OF SUCCEEDING WHEAT CROP

Doses of nitrogen (lb.)	Hansi		Jullundur	
	Average yield of wheat (grain) (mds.)	Increase over control	Average yield of wheat (grain) (mds.)	Increase over control (mds.)
0	5·2	—	5·7	—
25	4·7	0·5	6·4	0·7
50	5·3	0·1	6·8	1·1
75	6·8	1·6	7·8	2·1
100	7·9	2·7	8·7	3·0
125	9·5	4·3	10·1	4·4

It will be observed that similar residual effect was noticed at both the centres at which the experiment was carried out. The residual effect was observed in all the doses of nitrogen included in the experiment but it was very marked in the case of higher doses. It seems, therefore, that the nitrogen unutilized by the cotton crop remains fixed in the soil and benefits the following wheat crop.

Source of Nitrogen. Experiments have also been conducted to find out the best source of nitrogen in organic fertilizers. The results obtained by Gursham Singh and Kanwar Singh (1957b) are summarised in Table 44.

TABLE 44. YIELD OF COTTON AS INFLUENCED BY DIFFERENT SOURCES OF NITROGEN

Source of nitrogen	Yield of *kapas* per acre							
	50 lb. nitrogen				100 lb. nitrogen			
	Abohar	Jullundur	Hansi	Mean	Abohar	Jullundur	Hansi	Mean
Chilean nitrate	18·8	13·5	15·2	15·8	21·6	13·0	15·7	16·8
Ammonium sulphate	16·8	14·0	14·0	14·9	19·0	13·5	16·2	16·2
Urea	18·6	13·9	14·5	15·7	21·6	13·7	15·7	17·0
Ammonium sulphate nitrate	17·9	13·8	15·2	15·6	19·4	13·4	15·8	16·2
Control	12·5	12·4	10·9	11·9	12·5	12·4	10·9	11·9

It will be observed that the yield of cotton showed an appreciable increase over the control by application of nitrogenous fertilizers. The source of nitrogen, however, made no difference. On the basis of these results, any one of the fertilizers, chilean nitrate, ammonium sulphate, urea or ammonium sulphate nitrate can be recommended for application to the cotton crop in accordance with the availability of the fertilizer and the price per lb. of nitrogen.

In another experiment conducted at Hansi, ammonium chloride was tested against other nitrogenous fertilizers at 50 lb. dose of nitrogen and the results obtained are given in Table 45.

TABLE 45. EFFICACY OF AMMONIUM CHLORIDE AS AGAINST OTHER FERTILIZERS IN INCREASING YIELD OF COTTON

Source of nitrogen	Yield of *kapas* (maunds per acre)
Ammonium sulphate	18·49
Ammonium sulphate nitrate	18·38
Ammonium chloride	17·62
Urea	18·86
Control	13·24

It will be observed that while ammonium chloride gave a slightly lower *kapas* yield per acre as compared to ammonium sulphate, ammonium sulphate nitrate and urea, the difference was not very marked.

Time of Application of Nitrogenous Fertilizers. Some evidence has also been obtained regarding the best time of application of the inorganic fertilizers. Experiments conducted by Afzal (1949) at Lyallpur for four years (1929-32) indicated, though not conclusively, that the proper time for the application of ammonium sulphate and sodium nitrate was the end of August or the beginning of September, when the cotton plants are at the flowering stage. Investigations of Madhok and Fazaldin (1939) brought out the fact that soils are generally deficient in the available nitrogen at this time. Application of readily available nitrogen from any source at this particular time is, therefore, absolutely necessary for the proper nourishment of the developing bolls. This finding was confirmed by Dastur (1944) as can be seen from the data given in Table 46.

In contrast to the results at Lyallpur by Afzal and Dastur, the evidence obtained from experiments conducted at Hansi show that the application of half the dose of ammonium sulphate at the time of the thinning of the crop and the second half near the flowering phase gave slightly better results than application of the full dose at the pre-flowering stage, though the differences

TABLE 46. COMPARISON BETWEEN PRE-SOWING AND PRE-FLOWERING TIME FOR APPLICATION OF FERTILIZERS

Experiment No.	Doses of N in ammonium sulphate	Increase in yield due to application of manure		S.E. ±
		Applied before sowing	Applied in August	
4	48	8·10	9·25	1·03
14	32	3·59	4·59	1·79
30	48	5·40	5·05	0·80
50	32	3·49	4·85	1·13
47	32	1·32	4·02	0·84

observed were not statistically significant. The data obtained at Hansi are given in Table 47.

TABLE 47. COMPARISON BETWEEN APPLICATION OF FULL DOSE AND SPLIT DOSE OF NITROGEN ON YIELD OF COTTON

Scheme of application of ammonium sulphate	Yield of *kapas* (maunds per acre)							
	N0	N25	N50	N75	N100	N125	N150	Mean
1. Half at thinning and half at flowering	9·0	14·9	14·3	17·2	17·4	16·2	17·0	16·2
2. Full dose at flowering	10·5	12·4	13·4	16·0	15·5	16·7	16·0	15·0
Increase over treatment No. 2	—	2·5	0·9	1·2	1·9	0·5	1·0	1·2

In experiments carried out in Uttar Pradesh, the best time for application of the fertilizer was found to be at sowing time (Dabral, 1955).

Relationship of Nitrogen with Soil Salinity. The studies of Dastur (1944) in connection with periodic and partial failure of American cottons in the United Punjab showed that the response of ammonium sulphate depended on the extent of soil salinity. If the sub-soil was free from salinity, good response to the application of the fertilizer was obtained, as is clearly shown by the data given in Table 48.

TABLE 48. RESPONSE TO APPLICATION OF NITROGEN AS INFLUENCED BY SALINITY OF SOIL

Nature of soil	Increase in yield per lb. of nitrogen	Remarks
Light sandy soil free from salinity	8·84	Average of 9 experiments
Light sandy soil, saline sub-soil	7·28	Average of 7 experiments
Sandy loam, saline sub-soil	2·13	Average of 5 experiments
Sandy loam, highly saline sub-soil	1·05	Average of 4 experiments

Though no studies bearing on the above aspect have been carried out directly in the Northern Region, it is quite possible that the findings of Dastur would be fully applicable to the cotton crop of this Region. As mentioned earlier, the soils of Northern Region are impregnated with alkali salts. Their intensity is being further increased due to the rise in water table caused by increase in canal irrigation. It is, therefore, necessary to take note of this development and adopt corrective measures. The findings of Balasundram and Srinivasan (1955) reveal that application of carbonaceous material, such as straw, grasses, cotton stubbles, etc., reduces the loss of nitrogen from fertilizers very considerably. Work on these lines, therefore, requires to be initiated in the Northern Region.

Relationship Between Application of Nitrogen and Rotation. The response to the application of 50 and 100 lb. of nitrogen to cotton was found to be different in different rotations as will be observed from the data of Negi and Kanwar Singh (1956b) presented in Table 49 (page 48).

It will be observed that the application of nitrogen was beneficial in all the rotations, but the highest increase in yield was obtained by the application of the fertilizer to cotton following a wheat crop.

Relationship of Application of Nitrogen with Sowing Time. From their sowing date experiment, Dastur (1944), Dabral (1955) and Gursham Singh and Atwal (1955) concluded that, though application of nitrogen significantly increased the yield in all the sowings, the increase was highest in the early-sown crop. The recent experiments conducted under the Cotton Manurial Scheme in the Punjab on this aspect are very illuminating and their results as reported by Gursham Singh and Kanwar Singh (1957a) are presented in Table 50.

TABLE 50. INCREASE IN YIELD OF *Kapas* MANIFESTED BY APPLICATION OF NITROGEN IN DIFFERENT SOWING DATES

Place of trial	End April			Mid May			Early June		
	N0	N50	N100	N0	N50	N100	N0	N50	N100
Abohar	12·5	18·1	20·9	12·5	16·9	19·6	12·2	16·0	17·4
Jullundur	12·5	16·3	17·2	12·3	14·2	14·9	8·3	10·1	11·0
Hansi	10·2	14·8	17·7	10·5	13·9	15·4	8·5	11·0	11·6
Mean	11·7	16·4	18·6	11·8	15·0	16·6	9·7	12·4	13·3
Increase over control	—	4·7	6·9	—	3·2	4·8	—	2·7	3·6
Percentage increase over control	—	40·1	59·0	—	27·1	40·7	—	27·8	37·1
Increase in yield of *kapas* per lb. of nitrogen	—	7·7	5·7	—	5·2	3·9	—	4·5	3·0
Net profit	—	100	126	—	55	63	—	40	27

TABLE 49. RESPONSE TO APPLICATION OF NITROGEN TO COTTON IN DIFFERENT ROTATIONS

Place of trial	Average yield of *kapas* (maunds per acre) after the preceding crops														
	Guara			Gram			Berseem			Wheat			Fallow		
	N0	N1	N2	N0	N1	N2	N0	N1	N2	N0	N1	N2	N0	N1	N2
Abohar	21·5	24·2	25·7	16·5	21·5	24·3	17·6	22·5	25·5	14·7	19·6	23·7	19·8	24·2	26·0
Jullundur	18·2	18·8	18·9	16·5	18·2	18·7	17·9	19·1	20·2	14·0	17·8	18·9	19·0	20·2	20·5
Hansi	11·1	15·7	18·7	11·4	15·5	18·1	9·3	13·8	17·2	8·0	11·9	15·9	13·8	16·2	19·1
Mean	16·9	19·6	21·1	14·8	18·4	20·4	14·9	18·5	21·0	12·2	16·4	19·5	17·5	20·2	21·9
Mean Increase	—	2·7	4·2	—	3·6	5·6	—	3·6	6·1	—	4·2	7·3	—	2·7	4·4
Increase per lb. of nitrogen		3·8			5·0			5·3			6·3			3·9	

The above data show that the percentage increase over control as also the increase in the yield of *kapas* per lb. of nitrogen and the net profit were the highest in the earlier sowings done at the end of April and these decreased progressively as the sowings were delayed.

Application of Phosphatic Fertilizers

In early experiments conducted up to 1930 by the Punjab Department of Agriculture, no marked response to the application of phosphatic fertilizers was observed. Panse (1953) also came to the same conclusion while summing up the results of manurial trials conducted in the United Punjab. Dastur (1944) also arrived at a similar conclusion in his studies relating to *tirak* of cotton crop.

In more recent experiments, Negi and Kanwar Singh (1956) found that the application of superphosphate at 50 lb. P_2O_5 per acre to the preceding leguminous crop of *berseem* in the rotation not only benefited the fodder crop directly but also had a marked residual effect on the yield of the succeeding cotton crop. The results reported by these authors are given in Table 51.

TABLE 51. RESPONSE BY *Berseem* CROP TO APPLICATION OF P_2O_5 AND ITS RESIDUAL EFFECT ON YIELD OF SUCCEEDING COTTON CROP

Place of trial	Yield of green fodder from *berseem* (maunds per acre)							
	1952-53		1953-54		1954-55		Average	
	P_0	P_1	P_0	P_1	P_0	P_1	P_0	P_1
Abohar	146	212	314	409	118	158	193	260
Jullundur	644	686	716	730	544	568	635	661
Hansi	86	104	580	728	273	333	313	388
Mean	292	334	537	622	312	353	380	436
	Yield of *kapas* per acre due to residual phosphatic effect							
Abohar	20·3	22·7	22·4	23·1	20·6	21·5	21·3	22·4
Jullundur	22·8	22·5	22·7	23·7	11·2	11·4	18·9	19·2
Hansi	13·2	14·3	10·5	12·4	14·4	15·9	12·7	14·2
Mean	18·8	19·8	18·5	19·7	15·4	16·3	17·6	18·6

It will be observed that with the application of 50 lb. of P_2O_5 per acre, from superphosphate additional yields of one maund of *kapas* and 56 maunds per acre of *berseem* fodder were obtained on an average of three years' data collected at three different centres, viz., Abohar, Jullundur and Hansi. After deducting the cost of the fertilizer, a net saving of Rs. 28 per acre was realized in this experiment. The application of phosphate to the *berseem* crop sown in rotation with cotton can, therefore, be recommended with advantage in all the cotton-growing tracts of the Punjab.

Application of Potassic Fertilizers

The only experiments reported in the literature relating to experiments on potassic fertilizers are those of Dastur (1944). Working in the united Punjab with doses ranging from 48 to 350 lb. K_2O per acre, he found no beneficial effect of any of the doses on the yield of the cotton crop. On the other hand, the yield was depressed in some cases. Even the combination of potassic and phosphatic fertilizers was found to be ineffective.

Application of Organic Manures

Experiments carried out at Lyallpur and Hansi with the application of farm yard manure gave an increase of 118 and 281 lb. of *kapas* per acre, respectively. In Uttar Pradesh an increase of 82 and 114 lb. of *kapas* per acre was realised at Raya and Kanpur with the application of four tons of farm yard manure per acre.

In recent complex experiments conducted under the Scheme for Manurial Trials in the Punjab, two doses of farm yard manure, 150 and 300 maunds per acre were tried. The yield of seed cotton obtained due to farm yard manure against control (F_0) is depicted in Table 52.

TABLE 52. YIELD OF *Kapas* (maunds) DUE TO APPLICATION OF FARM YARD MANURE
(F_1=150 mds. per acre; F_2=300 mds. per acre)

Year	Abohar			Hansi			Jullundur		
	F_0	F_1	F_2	F_0	F_1	F_2	F_0	F_1	F_2
1956-57	14·0	16·9	18·3	15·3	16·7	18·3	10·4	11·0	11·1
1957-58	17·4	18·6	19·6	8·4	8·6	9·3	5·8	6·0	6·1
1958-59	7·1	7·7	8·7	9·9	11·3	11·0	9·0	9·0	8·2
Mean	12·8	14·4	15·5	11·2	12·2	12·9	8·4	8·7	8·5
increase over control	—	+1·6	+2·7	—	+1·0	+1·7	—	+0·3	+0·1

Though these trials have given beneficial results, farm yard manure is not very extensively used by the farmers for manuring their cotton crop. This is because the quantity of farm yard manure available with them is limited and whatever small quantity is produced in the whole year is generally utilized for manuring of sugarcane or fodder crops. In order to find out an alternative source of organic nitrogen, experiments have been carried out with different green manures, such as sannhemp (*Crotalaria juncea*) and *guara* or cluster bean (*Cyamopsis psoralioides*). In drier parts of the Northern Region, *guara* has been found to be a better green manure crop than sannhemp.

In recent experiments conducted at three different centres of the Punjab, viz., Abohar, Jullundur and Hansi, the effect of *guara*, as green manure, was studied on the yield of cotton in two rotations, viz., green manure-fallow-cotton-wheat and wheat-cotton-wheat. It may be mentioned that the second rotation is the most commonly used by the cotton growers in the Northern Region. The results obtained are summarised in Table 53 (I.C.C.C., 1958).

TABLE 53. COMPARISON OF YIELD OF COTTON OBTAINED AFTER WHEAT AND GREEN MANURING

Previous crop	Yield of cotton (maunds per acre)			Residual effect on the yield of succeeding wheat crop (maunds per acre)	
	Abohar	Jullundur	Hansi	Jullundur	Hansi
Wheat	13·2	8·9	5·9	7·9	4·0
Guara (green manure)	15·7	10·6	11·3	10·1	5·6

It will be seen that there was an increase of 34 per cent. in the yield of cotton due to green manuring and an increase of 32 per cent. in the yield of the succeeding wheat crop due to the residual effect of green manure.

The other sources of organic nitrogen are the commercial cakes, such as *toria*, groundnut, *mahua*, castor and *neem* cakes. Some of them are good cattle feeds but costly to transport. However, the efficacy of groundnut cake, as a source of nitrogen was studied in the experiments of the manurial scheme of the Punjab. The groundnut cake in its finely powdered form was applied and thoroughly mixed with the soil after sowing and before the application of first irrigation; ammonium sulphate for comparison was applied round the plants, half at the thinning and half at the pre-flowering stage. The average increase in the yield of *kapas* for the three years (1952-54) due to ammonium sulphate, groundnut cake and half-and-half mixture of the two on an equal nitrogen basis over control is given in Table 54.

TABLE 54. EXCESS IN YIELD OF *Kapas* (maunds) OVER CONTROL DUE TO GROUNDNUT CAKE, AMMONIUM SULPHATE, ETC.

Station	Ammonium sulphate		Groundnut cake		Mixture	
	50 lb. N	100 lb. N	50 lb. N	100 lb. N	50 lb. N	100 lb. N
Abohar	6·7	10·1	2·9	6·6	5·0	7·6
Hansi	5·1	8·6	3·2	6·5	3·3	5·7
Jullundur	5·7	6·2	2·4	4·3	4·2	5·6
Mean	5·8	8·3	2·8	5·8	4·2	6·3

The yield was the highest in the case of ammonium sulphate, followed by a half-and-half mixture of the two, while it was the lowest for groundnut cake. It is apparent that ammonium sulphate as a source of nitrogen is more potent than groundnut cake.

DISEASES AND PESTS

A number of insect pests and diseases attack the cotton plant in the Northern Region. Amongst diseases, root rot, *tirak* ('bad opening' of bolls) and angular leaf spot; and from amongst pests, pink bollworm, spotted bollworm, leaf roller, jassid, field cricket, *Chrotogonus*, white fly and cotton thrips are of common occurrence in the Northern Region. A very brief account of their life history, mode of attack and control measures is given below:

DISEASES

Root Rot: It occurs in the entire Northern Region and is caused by *Rhizoctonia solani* Kuhn and *R. bataticola*, soil-borne fungi. The disease makes its appearance in June, after the first irrigation, when the plants are about six weeks old. The attack continues in July; begins to decline in August and stops by the end of September. It has been established that frequent irrigations and a heavy soil moisture of 15-20 per cent. favour the development of the disease, whereas, low soil moisture (5 per cent.), low soil temperature and high atmospheric humidity discourage it (Vasudeva, 1936).

All of a sudden the plants, which were healthy only the previous evening are found withered the next morning. Sometimes a wilting plant may recover during a cool night or in the wet weather; but this is rare. The dying plants occur in patches; and the patches go on widening as more plants die. Sometimes big patches are formed and the yield is considerably reduced. In diseased plants the lateral roots decay; the bark tissue of the roots is shredded; a deposit or yellow granular substance is found under the root bark and the woody cylinder turns yellow (Vasudeva, 1935).

No commercial resistant variety or a really effective method of control has yet been discovered. However, investigations of Vasudeva (1936, 1941a) have indicated, that, because of the periodicity in parasitic activities of the pathogens, the disease can be evaded by sowing cotton very early (first week of April) or very late (end of June). It has been shown by Luthra and Vasudeva (1941) and Vasudeva (1941b) that intercropping of cotton with *moth* (*Phaseolus aconitifolius*) has a marked influence in reducing the root rot. Most probably, it creates unfavourable conditions for the casual fungi as it raises humidity within the crop and also, by covering the soil, lowers its temperature. The reduction in the incidence of the disease was also obtained by the application of calcium chloride and potassium chloride at the rate of 2,281 and 210 lb. per acre, respectively (Vasudeva, 1945).

All the imported American varieties and the indigenous types have been found to be susceptible to the disease under field conditions. However, *G. arboreum* var. *typicum* f. *indica* (*Rozi* cotton) has been found to show a high degree of field resistance.

Tirak (*'Bad Opening' of Bolls*): 'Bad opening' of bolls or *tirak* is neither a fungus nor a bacterial disease, but it occurs in American cottons only as a result of some physiological derangement in the plant. On account of this disease, cotton failures occurred in the Punjab in 1919, 1920, 1926, 1927, 1928, 1931, 1932 and 1939, which caused great financial losses to the growers. This disease is of commoner occurrance in West Punjab and Sind, and in a milder form in South-western zone of the region, where the conditions are arid. In other zones of the region its occurrence is rare.

The symptoms of the disease are early yellowing and defoliation of leaves, premature cracking of bolls containing immature and poor lint and seed, and low seed weight. All these factors bring about a considerable reduction in yield. The disease may occur in small or big patches or in the entire field in certain years. The symptoms of the disease are associated with accumulation of 'tannin' in leaves, which gives black colour with osmic acid. If a positive 'tannin' test is established before the drooping and yellowing of leaves, it shows *tirak* is imminent (Dastur, 1944).

According to Dastur (1941-1944) *tirak* occurs at places, where sub-soil at a depth of two or three feet, contains abnormal amounts of sodium salts; and in light sandy soils deficient in nitrogen. Under unfavourable weather conditions (long spell of warm and dry days during fruiting stage) and restricted water supply, *tirak* may appear even in fields having a low salinity. In normal seasons, *tirak* does not occur on such soils.

In soils of high salinity in the sub-soil, more frequent irrigations during the fruiting stage lessens 'bad opening' to a considerable extent. In light sandy soils, deficient in nitrogen, application of nitrogenous fertilizers particularly at the pre-flowering stage has a greatly ameliorative effect. The best and natural remedy under all soil conditions is to resort to late (June sowing) so that the plant size is reduced and it does not suffer from a water deficiency at the flowering stage. In the event of late sowing, it is necessary to space the plants closely, in order that the population per acre is higher, and the yield, lowered by the reduced plant size, is made up by their larger number.

Angular Leaf Spot: This disease is caused by *Xanthomonas malvacearum* (E. F. Sm.) Dow. All the *hirsutum* strains of the Northern Region are susceptible, but the *arboreum* types are highly resistant to the attack of this disease. The disease occurs in certain years of heavy and continuous rainfall, but its lesions remain restricted to leaves. It is only in very rare cases that the lesions spread to the stems and bolls to assume the proportion of blackarm and boll rot.

Water-soaked dark green spots, which become brown or black, appear on the lower side of the leaves. Later, these spots appear on the upper surface as well. Bacteria enter through stomata, destroy cell walls, liberate cell contents; giving the appearance of water-soaked spots. The lesions are bounded by larger veins and so appear to be angular. Often the lesions extend along the edge of the veins. This is called vein blight. The affected leaves become yellow and drop. In case of heavy defoliation, young bolls and squares also drop, the growth and development are interfered with and there is a reduction in yield. In rare cases, lesions of the disease appear on bolls, infecting one or more loculii.

The disease is carried over from year to year from the infected seed or the infected bolls and plant debris that remain in the field and impart primary infection. Rain and wind help in promoting and spreading the disease. The bacterial ooze from the lesions serves as inoculum, which is washed from leaf to leaf on to the soil by rain and is spread to the neighbouring field by wind-blown dust.

The primary infection of the disease is said to be satisfactorily controlled by the disinfection of the seeds with mercuric chloride-iodide, by soaking them for two hours in 1 : 500 solution and by the dressing of Abavit-B or Ceresan, other mercuric compounds. Delinting with sulphuric acid also gives fairly satisfactory control. Collecting and burning the infected plant remnants in large areas is helpful in reducing the carry-over of the disease from year to year. However, breeding of varieties resistant to this disease appears to offer the best means of avoiding the damage it causes. Genes for resistance are available from Upland Uganda B.31, *G. hirsutum* var. *punctatum*, *G. arboreum*, *G. barbadense* and *G. anomalum* (Knight, 1954). Simpson and Wielding (1946) discovered strain Stoneville 20, in which resistance behaves as a single recessive character. In Madras, strain 2196 has been found to be resistant under varied conditions of season and soil. The latter two strains may prove to be a good source for imparting resistance to the *hirsutum* varieties of the Northern Region.

PESTS

With the introduction and extension of the area under American cottons in the Northern Region, certain pests, which were considered previously to be of minor importance, inflict serious damage on the cotton crop at the present time. It is estimated that a toll of about 15 per cent. of the crop valued at about five crores of rupees is taken by these enemies every year. In certain years, when their infestation is heavy, 75 per cent. or more of the crop in certain localities may be spoiled. A brief account of the serious pests is given below:

Pink Bollworm (*Platyedra* (*Pectinophora*) *gossypiella* Saunders): In the Northern Region of India, it is particularly destructive in the South-eastern zone and parts of the North-western zone, where during the years 1956-57 and 1957-58, it reduced the yield to one-third of the normal and in addition impaired its quality.

The caterpillar stage of the insect does the damage by attacking squares, flowers and bolls. The infested squares are usually shed; the flowers do not open because of twisting and fastening together of their petals with the webbing spun by the caterpillar and fertilisation in such flowers does not occur due to the eating away of the essential parts by the pest. The caterpillar bores into the boll, but the hole gets healed up, making it difficult to differentiate between infected and healthy bolls. In the boll the larva eats the kernels of the seeds and prevents lint from reaching proper maturity. The lint remains short, weak and gets discoloured and almost valueless. The ginning percentage of the produce is reduced. The seeds remain immature and the quantity and quality of oil in them is impaired. Many a time 25 to 60 per cent. of the loculi are damaged resulting in a loss of yield from 20 to 50 per cent.

The incidence of the pest is usually heavier in American cottons than in the *desi* varieties (Hussain and Khan, 1940).

The caterpillar is pale yellow with a dark head and becomes pinkish, when full fed and measures about 15-16 mm. in length. The moth is small with a wing expanse of about 25 mm. It is dark brown in colour with numerous black spots (Nangpal, 1948).

With the approach of winter the fully fed caterpillar joins two seeds and hibernates inside them. Joined or double seeds, as they are called, are typical of pink bollworm infestation. A few of these larvae pupate in the end of March and moths appear in early April. The main rush of pupation occurs after the start of the monsoon and from these the adult moths emerge during July-August. The pest has two distinct life cycles: a short life cycle and a long one. In the short life cycle, the caterpillar after it is full fed, enters into pupation immediately and emerges as an adult. This happens during April-October in the Punjab. In the long life cycle, the caterpillars, however, enter into a long resting stage in double seeds and remain in this condition from 8 to 10 months or even 20 months in some countries. It is in this phase that the pest spreads to new places through commerce. In the Punjab this period extends from November to March.

The female moths have a life-span of about four weeks in the Punjab and about eight weeks in Uttar Pradesh. They lay a large number of eggs, either singly or in batches on leaves, squares, flowers and bolls, but mostly on the bolls. A female moth has been found to lay a maximum of 456 and 309 eggs in the Punjab and Uttar Pradesh, respectively. The eggs hatch in 3 to 12 days. The larva enters into square or boll and is full fed in 10 to 25 days. It comes out from the boll and pupates on the ground amongst shed leaves, flowers or under a clod. The pupal stage lasts from 6 to 20 days. The moth emerges and the life cycle is repeated. Three to four overlapping short life cycles are repeated from August to October in the Punjab and four to five during July to the end of November in Uttar Pradesh.

Favourable conditions for the pest are warm, but not excessively hot, weather, cloudiness, and frequent, but not excessive, rains. Long spells of dry hot weather are not conducive to a rapid multiplication of the pest. Its heaviest incidence is noticeable in October and November.

The pest hibernates in cotton seed in the stores, or in the bolls left on the stored cotton sticks, under the fallen leaves, in the soil and in *patti* (refuse from openers) in ginneries. A concerted effort should be made to destroy the pest at all these places, in order to minimise its carry-over from year to year. In this connection the adoption of the following steps is advocated.

1. After harvesting cotton sticks and before the end of March and in no case later than May, all the dried leaves and fallen bolls should be collected and burnt.
2. The fields vacated by cotton should be irrigated and ploughed with a furrow-turning plough for destroying the hibernating larvae in the soil crevices. If practicable some *rabi* crop should be sown immediately after harvesting cotton, such as gram in South-eastern districts of the Punjab and field pea in Uttar Pradesh.
3. Cotton sticks meant for fuel should be consumed by the end of May at the latest and the plant remnants underneath should be collected and burnt.
4. All the ginning factory refuse, collected as a result of passing *kapas* through opener must either be composted, burnt or buried deep in the soil for killing the resting larvae that go into it.
5. The resting larvae in the double seeds can be killed by spreading the seed in thin layers in the sun for two or three consecutive days during the months of April and May, when the temperatures are generally high. A more effective method is fumigation of the seed before the end of March with methyl bromide at the rate of one lb. of fumigant per 1,000 cubic feet of space with exposure of 24 hours (Anon., 1959).

Killing the larvae in the seed meant for sowing is not enough, as large quantities of seed stocked as cattle feed and for the extraction of oil are a major source, from which moths may emerge and start infestation in the field. It is, therefore, essential that all the seed coming out of the ginneries should be fumigated.

Some recent experiments on the chemical control of the pest in the field in the Punjab (and Bombay) have shown that four to six sprays of 0.1 per cent. each of DDT and BHC suspension, and 0.02 per cent. endrin emulsion at fortnightly intervals help in reducing the incidence of the pink bollworm to about 50 per cent. of that in the control plots. Further work on this aspect is in progress.

An active braconid parasite of the pink bollworm, namely *Apanteles angaleti* Muesebeck was found at the Indian Agricultural Research Institute, New Delhi. Methods for its mass breeding and exploitation for the control of pink bollworm are under study (Narayanan *et al.*, 1956). A nematode parasitising pink bollworm larvae has been found in the U.S.A. This nematode is reared in large numbers in the laboratory and sprayed in water on the crop with sprayers. It is said to exercise a check on the spread of pink bollworm. It would be interesting to introduce and establish it in India.

In Texas (U.S.A.) mercury vapours and ultra-violet flourescent lamps are used in special traps for attracting pink bollworm moths. It would be interesting to conduct experiments on similar lines in this region.

To introduce resistance to pink bollworm in cultivated types from the wild species, like *G. anomalum* and *G. thurberi*, is a long-range research project. However, in the absence of resistant varieties, earliness in maturity has been made use of in evading this pest. As the incidence of the pest starts in July-August and becomes serious in October-November a variety early enough to open most of its bolls before the peak period of pink bollworm incidence will be able to escape from its ravages and will be able to give a good yield. Such a variety, namely H.14, has been developed under a scheme of the Indian Central Cotton Committee at Hansi (Avtar Singh and Negi, 1954, 1958) for the South-eastern tract of the region. It has been observed that as the cracking and opening of bolls in this variety is completed during October, most of them escape from being punctured by this pest and thus disease-free produce is obtained from them. The growing of early ripening strains, is, therefore, recommended in areas infested with this pest.

Spotted Bollworm—Earias insulana (Boisd) *and Earias fabia* (Stoll.): The two species of this pest *Earias insulana* and *Earias fabia* are found in the Northern Region. The latter usually predominates, but in some years the former may be as abundant as the latter.

In the initial stages of the plant growth the caterpillar attacks the terminal shoot, which droops and withers. Subsequently, the larvae attack buds, flowers and bolls. A larva usually migrates and may destroy many forms in its life time. The infected buds and flowers and young bolls are usually shed. The bigger bolls may remain on the plant and open prematurely yielding *kapas* of a poor quality, which is unfit for sale. It has been observed in the Punjab that up to 75 per cent. of flower buds and 59 per cent. of bolls may be damaged by this pest (Nangpal, 1948).

The moths of *Earias insulana* measure about 25 mm. in wing expanse. Its front wings are grass green in colour, but in some specimens they may be light green, yellow, brown or greyish brown. The hind wings are white. The *Earias fabia* moth has pea-green fore-wings with a wedge-shaped white band running medially from the base to the outer margin.

The newly hatched caterpillar is brownish white in colour with a dark head. When full fed, it is spiny with a dull greenish white body having black dots all over and orange spots on the prothorax. In length it is about 20 mm.

The spotted bollworms remain active throughout the year. Their population is the lowest during December-March. They begin to multiply in April-May, but are abundant during July-September. The moths lay eggs at night singly on terminal buds, squares, bolls and tender leaves. A female can lay up to 400 eggs in the Punjab. The eggs hatch in three to nine days. The caterpillars become full fed in 7 to 18 days. The larvae pupate on the plant during August-October and on the ground during November-December, or some may enter the soil for this purpose during winter. In Uttar Pradesh, they pupate in shed material or in the soil. The pupal stage lasts from 7 to 25 days during August-September and from 41 to 87 days during December-March.

The larvae and pupae of the spotted bollworm are parasitised by several parasites, the most important of which is *Microbracon lefroyi* (D. & G.). This parasite is common in the Punjab round about Rohtak and in certain years, particularly during years of heavy monsoon rainfall, it keeps the pest under check. It should, therefore, be encouraged.

Since it is an internal feeder, its insecticidal control is rather difficult. Some recent experiments have shown that 4-6 sprays of 0.1 per cent. each of DDT and BHC suspension and 0.02 per cent. endrin emulsion at fortnightly intervals help in reducing the incidence of the spotted bollworm to about 50 per cent. of that in the control plots. The following preventive measures to reduce the carry-over of the pest from year to year can go a long way towards keeping the pest under check :

1. In the beginning of the cotton season the withering shoots should be regularly removed and burnt to kill the larvae feeding inside.
2. When the pest is destroying reproductive forms, the plants should be given a thorough shaking by dragging a rope over them to dislodge the attached squares and bolls. This should be followed by watering immediately afterwards. The bollworms in the fallen attached buds and flowers on the ground will be drowned. If the irrigation facilities are not forthcoming, the shed material should be collected and burnt or buried deep into the soil.
3. After the cotton crop is over, the cotton sticks should be cut two inches below the soil level with *kudali* any time during January to March, so that they have no chance to sprout. In case sprouts appear, they should also be destroyed in April, as during January-April the pest feeds on cotton sprouts and in their absence it will get starved and killed. Wild host plants like *kanghi* (*Abutilon indicum* G. & D.), *kuchari* (*Malvastrum tricuspidatum* Ait. Gray), *sonchal* (*Malva parviflora*) and *vilayati kanghi* (*Abutilon hirtum*), found in the vicinity, should also be eradicated during January-April.
4. Sowing of an early crop of *bhindi* (*Abelmoschus esculentus Linn.*) in the neighbourhood of fields proposed to be sown with cotton should be avoided.

Cotton Leaf Roller (*Sylepta derogata* Fabr.): The pest attacks both American and *desi* varieties of cotton, though it has a special preference for the former. It was considered to be a pest of minor importance, but with the spread of

American cotton, it has become one of the major pests in the Punjab (India). It becomes endemic in certain years and does considerable damage to the American cotton in sub-montane and the central districts of the Punjab. It also does appreciable damage to American cotton in the *tarai* area of Uttar Pradesh. Its alternate host plants are *bhindi*, hollyhock (*Althaea rosea*), *kanghi*, *kuchari*, etc.

It is the caterpillar that does the damage. It is active during rainy season. When young, it feeds on the lower surface of the leaf, but after the first mount, it rolls the leaf from the edge towards the mid-rib forming a trumpet-like structure in which it feeds. The major portion of the attached leaf is eaten away and in the remaining portion big holes are made. The attached leaf drops off the plant. In the event of heavy attack, the plants lose all leaves. When disturbed the caterpillar actively comes out of the trumpet and drops to the ground and ascends another plant. In severe case of infestation, 3,000 caterpillars may be found in an area of 100 square feet.

The moth is 12-13 mm. long with a wing expanse of about 25 mm. It is yellowish-white in colour and its wings are spotted with brown, waxy dots and zigzag lines. The caterpillar is about 30 mm. long when full fed. It is shiny greenish in colour with a dark brown head and prothorax. It becomes pinkish before pupation.

The insect passes the winter as a full grown pinkish larva amongst fallen leaves and flower buds. The larva pupates in the second week of February and the moth emerges in March. The eggs, which are smooth, white and flat are laid singly along thick veins, usually on the lower surface of the leaves. Yellowish larvae hatch out of them in 4 to 6 days and are full grown in 12-24 days. The pupal stage lasts five to eight days during the active season. The pest is active up to the end of October during which period 4 to 5 overlapping generations may occur. The pest causes most of the damage during the rainy season (Nangpal, 1948).

The following measures have been found useful in the control of this pest.

1. In the early stages of attack, collecting the rolled leaves and putting them in a bucket containing kerosenised water for killing the larvae is helpful in checking the spread of this pest (Sawhney and Sikka, 1955).
2. Irrigation and ploughing of the infested field after the cotton sticks have been harvested will go a long way towards killing the over-wintering larvae, resulting in a marked reduction of the carry-over of the pest.
3. Eradication of the alternate host plants during April-August is also helpful in checking the carry-over of the pest to next year.
4. Spraying the crop with 0.15 per cent. BHC suspension (one lb. of 50 per cent. BHC w.p. in 33 gallons of water) or 0.25 per cent. lead arsenate suspension (one lb. lead arsenate in 40 gallons of water) at the rate of 80-100 gallons per acre is effective against the pest.

The cost of the treatment comes to Rs. 2 to Rs. 3 per acre (Anon., 1959; Sardar Singh and Ajit Singh, 1958).

5. Certain experiments showed that there was a greater incidence of the pest of the pre-monsoon sown crop than on the post-monsoon one (viz., July) in Uttar Pradesh. Further work to study the advisability of pre- and post-monsoon sowings from the practical and economic point of view should be undertaken, so that the crop can be saved from this pest.

Cotton Jassid (*Empoasca devastans* Distant): This pest is serious in the Northern Region and does damage to American cotton. It also causes damage to *bhindi*, potato, brinjal, french beans and hollyhock.

It does damage both in the nymphal and adult stages by sucking sap usually from the underside of the leaves. The infested leaves get crumpled with edges turned downwards. Ultimately the leaves become red, dry up and are cast off. Due to the drain on sap and drooping of leaves, the attacked plants remain stunted and their fruiting capacity is seriously affected.

The pest appears almost every year, but in certain years it becomes virulent. Its damage is maximum during July-September.

The adult insects are wedge-shaped, about 3-4 mm. in length, pale green in summer and reddish in winter. The front wings have a black spot on their posterior parts and there are two black dots on the vertex at the head. The nymphs resemble the adults except that they are wingless.

The insect remains active throughout the year. During winter, it has been observed on the potato crop, from where it shifts on to brinjals and hollyhock in April and from there to American cotton and *bhindi*. In a year, it passes through nearly a dozen generations. The life cycle is completed in 15 to 46 days according to season. A female adult can lay up to 29 eggs, which are light yellow in colour. The eggs are laid in the tissue of bigger veins on the underside of the leaves. They hatch in 4 to 11 days. The nymphs are full-grown in 7 to 21 days after moulting for five times (Nangpal, 1948).

Though spiders and ants have been found to feed on this pest, they are not effective in keeping down its population. The pest can be controlled by spraying the crop with 0.1 per cent. DDT suspension (one lb. of 50 per cent. w.p. in 50 gallons of water) or 0.02 per cent. endrin emulsion (one lb. of 20 per cent. endrin e.c. in 100 gallons of water) at the rate of 80-100 gallons of spray material per acre. The cost of insecticide is about Rs. 5 in case of DDT and Rs. 6 to Rs. 7 in case of endrin (Anon., 1959; Sardar Singh *et al.*, 1958).

Adoption of the following preventive measures will be helpful in keeping down the infestation of this pest :

1. It has been observed that American varieties of cotton with non-hairy or sparsely hairy plant-body suffer most from the attack of this pest,

whereas the hairy varieties are comparatively resistant. The cultivation of varieties with a hairy plant-body, such as P.A. 320F, P.A. 216F and P.A. H.14 should, therefore, be widely adopted.

2. Late sowing of cotton, i.e., after the end of May should be avoided as far as possible as late-sown crops suffer more from this pest than those sown early.
3. Close spacing, regular and thick stand is advocated as it helps in keeping down the jassid population.

Field Cricket (*Gryllus viator* Kirby): Usually it is a minor pest. Both the adults and nymphs are destructive. During day-time, the field crickets enter the soil cracks or remain under clods. At night, they emerge from the place of their hiding and cut the germinating seedlings at ground level and eat away the cotyledons. In the South-eastern zone it becomes serious in years when the stand of the crop is adversely affected, necessitating re-sowing in extreme cases. Dry weather conditions are favourable for its abundance. Its incidence is particularly high in heavy land (where either cracks or clods afford it protection during day) from the month of May until advent of rains.

Some birds, such as the Indian *myna* (*Acridotheres tristris tristris*), Indian roller (*Coracias indica*) and large cuckoo shrike (*Grancalus macii*) prey on it, when it gets exposed during cultivation of the land.

The chief preventive measure is to sow cotton early in April, so that by the time the pest becomes serious in May, the stems of the plants are woody enough to resist damage from the pest.

Dusting the field with 10 per cent. BHC at the rate of 15 to 20 lb. per acre is effective against the insect. The cost of the pesticide works out to be Rs. 3 to Rs. 4 per acre (Anon., 1959).

Chrotogonus (*Chrotogonus trachypterus* Blanchard): Though otherwise a minor pest, it becomes serious in certain years. Both the adults and hoppers destroy the seedlings. The adult is a strongly built, flat, small-sized, dust-coloured grass-hopper. It is a general feeder and is found to damage most of the crops.

Dusting the field with 10 per cent. BHC at 15 to 20 lb. per acre is effective against this pest. The cost of the pesticide works out at Rs. 3 to Rs. 4 per acre (Anon., 1959).

White Fly (*Bemisia tabaci* Genn.): Its incidence is sometimes high in drier districts, particularly in some parts of Ferozepur and Bhatinda districts of the Punjab and Sriganganagar tract in North-west Rajasthan.

The adult is a small insect measuring 1-1.5 mm. in length, with a yellow body, which is lightly dusted with waxy powder. Its hind legs are a little longer than the other legs.

The pest is active throughout the year. It is most destructive to cotton during April-September. During November, it migrates to rape, cauliflower, turnips, *sarson*, *toria* and potatoes and then to hollyhock, cucurbits, *bhindi* and ratoon cotton, etc., in the end of March.

It is a pest of both the *desi* and American cottons. The pest is harmful in the adult as well as the nymphal stages. It sucks sap from the leaves and lowers the vitality of the plant. It also secretes honeydew, which covers the leaves on which the sooty mould develops, thereby interfering with the photosynthetic activity of the plant. The attacked crop gives a blackened appearance. In case of heavy infestation, the growth of the plants is seriously arrested and their yield is reduced considerably.

The pest is controlled by spraying 0.15 per cent. BHC suspension (one lb. of 50 per cent. w.f. in 33 gallons of water) or 0.02 per cent. endrin emulsion (one lb. endrin e.c. 20 per cent. in 100 gallons of water) at 80-100 gallons per acre. In the former case the cost is Rs. 2 to Rs. 3 and in the latter Rs. 5 to Rs. 7 per acre (Anon., 1959; Sardar Singh *et al.*, 1958).

Cotton Thrip (*Thrips tabaci* Lindeman): This pest is usually found on onions, but in certain years it causes damage to young American cotton plants.

The adult is a straw-coloured insect measuring one millimetre in length. It has delicate wings with long hair on edges.

Both the adults and nymphs do damage. They scrape epidermis and suck sap. The attacked leaves become whitish initially, crumple up and turn pale brown. Ultimately the leaf or the shoot is killed.

The pest can easily be controlled by spraying 0.1 per cent. DDT suspension (one lb. of 50 per cent. w.p. in 50 gallons of water) at 40-60 gallons per acre.

The cost of the insecticide is about Rs. 1.80 per acre (Sardar Singh and Sidhu, 1959).

HARVESTING AND YIELD

HARVESTING

The cotton picking season in the Northern Region lasts from the middle of September to the end of November. The picking is invariably done by manual labour. Mostly women and small boys are employed for this purpose on a 'crop share' basis. The wages in kind vary from 1/4th to 1/16th of the quantity picked. In the first picking, when the yield is low, about 1/8th of the yield obtained is given away as wages to the pickers, while in the middle pickings, the share may vary from 1/12th to 1/16th. In the last picking, which gives the lowest yield, the share of the pickers may vary from 1/4th to 1/6th. On an average, 1/10th of the total crop goes as picking wages. A few progressive farmers pay the pickers in cash, this being less costly to the owner. The wages in this case vary from Rs. 2 to Rs. 2.50 per maund of *kapas* picked.

The number of pickings varies for *desi* and American cottons. In the former case, as there is a risk of the *kapas* falling off after the boll has fully opened, the picking is generally done at the shorter interval of seven to ten days, whereas in the case of American cottons, where such a risk does not exist, the entire crop is generally picked in three or four pickings, the interval between pickings varying from 15 to 20 days.

Some years ago there was a tendency on the part of the cotton growers to pick the cotton early in the morning when the dew is on the crop and also to place the picked cotton in wet water channels and on dewy grass to increase the weight of the *kapas*. This practice, however, has been practically abandoned in recent times because the grower has realised that wet cotton deteriorates in colour during storage and gets a low price for the produce when marketed. However, one defect which still persists is the picking of trashy cotton. Since the practice of defoliating cotton crop before picking is not pravalent in India, the dry bracts and leaves cling to the picked cotton, making it trashy. The system of getting the cotton picked on 'crop share' basis is also responsible to some degree for unclean picking of *kapas*, because the tendency on the part of the pickers in this system is to extract *kapas* as hastily as possible from the boll in order to pick the largest quantity to increase the wages.

YIELD

As compared to the all-India average of 77 lb. of lint per acre, the yield of cotton in the Northern Region was worked out at 177 lb. This yield is higher than that realised in any other cotton region of India.

Of the three States that constitute the Northern Region, the per acre yield of cotton is the highest in the Punjab, followed by North-west Rajasthan and Uttar Pradesh. As more than 83 per cent. of the cotton acreage of the region lies in the Punjab, the per acre yield of this State widely affects the overall yield of the Region. Because the Punjab has an excellent canal system with an assured water supply and the cultivators are progressive, the yield per acre in this State has been showing a progressive increase since the partition, as is evident from the figures given in Table 55.

TABLE 55. YIELD PER ACRE OF COTTON IN THE PUNJAB

Year	Yield (lb. per acre)	Remarks
1940-42	151	Pre-partitioned period
1943-45	155	
1946-48	116	Transition period
1949-51	184	Post-partitioned period
1952-54	228	
1955-57	201*	

* Unfavourable climatic conditions during all the three years.

It will be observed that during the transition period when, as a result of the partition, the conditions were uncertain and the migrants from West Pakistan had not fully settled on land, the production of cotton per acre was reduced to the low figure of 116 lb. of lint per acre. However, after the people were completely rehabilitated, the yield figure rose to 184 lb. per acre during the triennium 1949-51 and to 228 lb. per acre during the period 1952-54. During the triennium 1955-57, the average yield of cotton in the Punjab was 201 lb. of lint per acre. The slightly lower yields obtained during this period were mainly caused by the very unfavourable conditions which prevailed during three successive years, 1955-57. Despite this drop in yield, it is gratifying to note that the yield of partitioned Punjab is higher than that recorded during the pre-partition period. It has, however, to be conceded that the present day yield of cotton in this State is still much lower than that realized in such advanced countries, as Egypt, Russia, China, etc. Further vigorous efforts to increase yield are, therefore, necessary.

The chief factors responsible for the upward trend in yield in the Punjab were the introduction of improved varieties for different tracts; extension in irrigation facilities, greater use of inorganic fertilizers, and the introduction of line sowing and other improved cultural practices. However, there is still a considerable scope for further stepping up of yield. The stand of the crop in the fields of the growers is far from satisfactory. They are still in the habit of using a low seed rate in order to save the trouble of thinning. Ammonium sulphate and other similar fertilizers, a potent factor for increasing yield, is applied only by a small percentage of cultivators, and that too in inadequate quantities. Use of prophylactic measures to suppress pests and diseases is yet in infancy and the ravages, when pests and diseases appear, are great. The pest control laws are inadequate and do not cover all the pests, nor are they rigorously enforced. There is scope and need for producing still higher yielding types, resistant to pests and diseases. Amelioration along these lines will be very helpful in raising the yield of cotton to the desired level. It will not, however, be out of place to mention here that good growers, by adopting improved methods even now raise an excellent cotton crop and obtain as high an yield as 25 maunds of *kapas* (670 lb. lint) per acre on the average. From selected whole-acre fields an yield of 30 maunds per acre (800 lb. lint) has been obtained, whereas the maximum yield obtained in the Punjab has been over 40 maunds of *kapas* (over 1,000 lb. lint) per acre at Sirsa Agricultural Farm, in the early years when the farm had just been started and the land was virgin. This indicates that by adoption of improved methods of cultivation, it should be possible to attain an average yield of 15 to 20 maunds of *kapas* (400 to 500 lb. lint) per acre, which will put the Punjab at least on a level with the countries advanced in cotton culture.

MARKETING AND GINNING

MARKETING

Seed cotton or *kapas*, as it is picked from the fields, is readily saleable without any processing. Here it is sold as such, though in advanced countries, like the United States of America, the farmers get it ginned and dispose of lint and seed separately. They, thus, have been able to eliminate one of the major middlemen from amongst the chain of the intermediaries that exist between the producer and the consumer. In northern India, the process of marketing lint and seed, instead of *kapas*, directly by the growers, is in its initial stages of development. The first experiences gained have been encouraging and it appears that this process may gain momentum in the near future.

Seed cotton (*kapas*) is sold by the growers in the villages to the petty shopkeepers as well as in the markets, situated in towns or in important centres.

Marketing in Villages. The village shopkeeper plays an important part in the economy of the farmers. He supplies to them various necessities of life on credit. He advances them cash loans on a good rate of interest. He mingles with them in their sorrow and happiness, and, thus, becomes indispensable, particularly to those small growers whose financial position is lean. In return, the poor producers either pay him in kind or sell their *kapas* to him. In some cases, the land holdings are small and, consequently, the produce of most of the farmers is generally small and it is not considered worth while by them to take it to the market. It is either sold to the village shopkeeper or the travelling cotton merchant. Again, the pickers, who usually get the wages in kind, sell *kapas* to the village shopkeeper in exchange of their day-to-day needs.

Disadvantages of Marketing in Villages : The village shopkeeper makes purchases at low prices and keeps a wide margin of profit. He has always the tendency to underweigh. The village merchant has to incur some expenditure on the transport of *kapas* for disposal in a bigger market, which ultimately is to be borne by the grower. As he usually purchases *kapas* in small lots, he mixes superior and inferior qualities and seldom gives premium for quality, but, on the other hand, purchases inferior cotton at a very much reduced rate. It has been estimated that the grower, on an average, gets 5-10 per cent. less value for the produce by selling in villages. The cultivators are aware of these disadvantages, but even then some of them do not take their produce to the bigger markets for fear of being duped by unscrupulous elements in the trade.

Marketing in Wholesale Markets. The *kapas* is taken to the markets mainly by carts, camels or donkey loads. Sometimes, cycle rickshaws are also used to bring in *kapas* loads. The carts and the animals are parked in front of the commission agent's shop. In the important markets situated in the Ferozepur district of the Punjab, the carts are unloaded and the produce is heaped for the inspection by the buyers. The produce is then sold by open auction, which is generally purchased either by a ginning factory, a cotton merchant, or a mill agent, who generally have local ginning arrangements. The delivery of the produce is given there in the market yard and the buyers make their own arrangements to transport *kapas* to the ginnery. In other markets of the Punjab, Uttar Pradesh and Rajasthan, cartloads of *kapas* are taken by the commission agents to the factory premises, where the *kapas* is examined by the buyer or his agent. Samples from it are taken and ginned. Taking the ginning percentage and other aspects into consideration, mutual bargaining between the commission agent of the cultivator, and the agent of the buyer, usually under cover of a piece of cloth, is carried on and eventually a price is struck. The grower is merely an onlooker and usually agrees to whatever price is settled. But in cases where the price offered by a factory-owner is too low and falls much short of the expectations of the grower, he takes his carts to the next neighbouring factory and tries his luck there. As soon as the *kapas* is sold and weighed, the commission agent pays the seller and realises the amount later on from the buyer after 3 or 4 days, according to the custom of the market.

Difficulties Experienced by Cultivators. In the wholesale markets, the growers are able to realise a much better price than the one they are able to get in villages, as there the number of buyers, who compete amongst themselves, is large. Even then serious difficulties have to be faced by the growers.

During the marketing season of cotton, there is a huge rush and congestion in the markets. There is hardly any suitable place for parking the carts and animals and heaping the *kapas*. Sometimes, *kapas* has to be heaped at odd places, very close to each other, on the road-side, and near drains. The *kapas* on the outskirts of the heaps falls into the drains or is trampled under feet. The *kapas* heaps get coated with dust that rises every time a vehicle passes along the road, and spoils its appearance. Many a time either the auction or the weighment of the entire *kapas* assembled in a market is not completed in a day, with the result that the grower is obliged to remain in the town over a winter-night, and is, thus, faced with the difficulties of seeking food and shelter for himself, his animals, and to keep watch over his unweighed *kapas*. In this way, he is put to trouble and expense.

The number of important buyers in a market is usually 10 or 12, and usually the same buyers operate in neighbouring markets. The cotton traders and mills through their agents have liaison with the local factory-owners, who act as buyers and ginners for them. The factory-owners sometime come to an understanding amongst themselves and do not out-bid each other in the auction after a certain limit has been reached. In this way, they are able to prevail upon the market and secure all the *kapas* with a good margin of profit to the detriment of the grower.

In the markets, where the system of auctions is not in vogue, the grower has to face certain difficulties. The commission agent engaged by him is not able to protect his interests, as he is liable to favour the buyer, while negotiating the price because the volume of turn-over of the commission agent depends upon the goodwill of the buyer. Secondly, even though the price of the *kapas* is arrived at after examining the *kapas* in the cart from all sides, and after taking samples from the middle and different parts, the buyer insists on *vatta* or quality allowance during the middle of a weighing on the plea that the quality of the *kapas* in the middle and bottom of the cart is not in keeping with that at the top. If the quality allowance is not accorded, the buyer refuses to take delivery of the remaining unweighed *kapas*. The seller has, therefore, to give in, or take the remaining *kapas* for sale to some other party, who may again turn out to be unscrupulous like the previous one. Further, the samples of *kapas* taken for examination and determination of ginning percentage are considerable in quantity and are seldom paid for. Again, the ginning percentage is determined under the plea that due premium will be allowed if it is found above the average, but more often, it is used as a lever to reduce the rate.

Other malpractices in vogue previously were over-weighing; *karta* or additional weight, taken over standard weight as a compensation for the supposed impurities in the produce; *muddat*, the compensation to cover the interest of the value of the produce paid to the grower, as the same was received by the commission agent from the buyer after 3 or 4 days; excessive commission charges; brokerage; weighing charges; servant fee; and charity, etc. But these have now been regulated and reforms brought about in the Punjab under the "Punjab Agricultural Produce Markets Act, 1939."

Regulated Markets. In the Punjab, practically all the important markets, numbering about 77, have been regulated under the "Punjab Agricultural Produce Markets Act, 1939." The act is applicable to cotton as well as most other commodities. In former Pepsu, the markets are supervised by the Marketing Board, and most of the markets come under its purview. Under the Punjab Act, the following major provisions guard the interests of cotton producers :

1. A majority of growers is provided in the constitution of the market committees.
2. Commission agents, brokers and weighmen operating in the market committee area are required to take out a licence.
3. All the weights and measures are open to checking.
4. Charges for different functionaries have been regularized and fixed.
5. Market committees arrange to provide shelter and drinking water for the grower and his animals.
6. Market committees arrange for storage of produce on payment.
7. Market committees encourage auctions and engage an auctioneer for this purpose.

Most of the above measures have been adopted by the market committees, and the others are underway. Under their bye-laws, the market committees have fixed a sum of Rs. 1.56 per cent. on the value of the commodity as merchandising charges, chargeable from the produce-seller. The details of these charges are as follows :

	Rs. nP.
Commission charges (per cent.)	1.00
Weighment charges	0.22
Brokerage	0.15
Other miscellaneous and labour charges	0.19
Total	1.56

Some Suggestions to Overcome Difficulties. With the coming into force of the "Punjab Agricultural Produce Markets Act of 1939", some of the difficulties of the growers have been removed and substantial relief has been accorded to them in fixation of merchandising charges on reasonable basis. However, there are other difficulties that need solution, and can be remedied by proper working of the Act, for which following suggestions are made.

1. Only such growers should be put on the market committees as are literate and capable of watching the interests of the growers.
2. Market committee areas should be widened and attempts should be made to regulate sales at distant places as well.
3. The market committee should obtain the previous evening's closing rates of key markets and, on their basis, work out local rates for *kapas* and exhibit the same at prominent places.
4. Technical guidance to the market committees should be provided by a board of technical men.
5. Each market committee should have an arbitration committee, to settle any disputes between buyers and sellers. Its intervention should be sought when undue *vatta* or quality allowance is being levied by the buyer.
6. Creation of producers' Co-operative Sales Societies.
7. Sometimes, the cultivator has to wait for a week to clear off his produce and thus put to a great inconvenience which forces him to sell off his produce at any rate to any buyer he comes across. There should be a provision in the Act to enable him to clear off his stock the same day.
8. The *kapas* should be weighed between 9 a.m. and 5 p.m. Weighing during the night, now a common practice, should be strictly prohibited.
9. The cotton should be insured and the insurance amount should be paid by the agent, who gets a commission from the seller for his services or nominal charges should be got from the seller, i.e., 6nP. for Rs. 100 (which comes to 2 nP. per maund of *kapas*).
10. The sale of *kapas* should be restricted within the market premises and, in no case should the transaction be made in the factory, where

great trouble is created by the buyer in the form of *vatta*, i.e., quality deductions.

The sixth suggestion is a potent method in the hands of growers to end all ills, if they join and work together on a co-operative basis. In this connection, an experiment is underway in the Punjab.

Co-operative Marketing of Cotton. Under this system, the small growers or co-operators, pool their produce and market it collectively, sharing the sale proceeds according to their contributions. This system has a number of advantages both for the producer and the ultimate consumer. The producers can withhold the sales, if the market trends are not favourable, and are in a position to store the produce and dispose it off, when the market becomes bullish. Some of the intermediaries and their charges are eliminated and the grower is able to get his due share in the consumers' rupee. The pooled produce, if so desired or found profitable, can be processed more easily and economically and sold as lint and seed. The producer becomes business-minded and he is able to watch his own interests. The experience so gained by him is utilized in his general farming. The consumer or the bigger trader, who deals with the co-operative society gets unadulterated stuff and is saved from the malpractices of the middleman and, therefore, is able to get a better value for his money. The formation of pools by local traders and ginners is discouraged, and a sense of healthy competition comes to prevail amongst the prospective buyers, and chances for the producer to get a fair deal increase tremendously.

The first venture of marketing *kapas* on a co-operative basis was made at Tarn Taran during 1950-51 by the growers, under the advice of the Department of Agriculture, Punjab, when 2,500 maunds of *kapas* was collected and auctioned at a premium of Rs. 2.75 per maund, resulting in an extra gain of Rs. 6,250 to the co-operators. During 1952-53, 4,000 maunds of *kapas* were assembled by the members of the co-operative societies, but the price offered to them by local traders in auction was less than the Bombay price. This encouraged the growers to withhold the sale of *kapas* and to process it and sell it as lint and seed. The ginning was arranged and the lint was sold directly to a mill, at a handsome premium to the entire satisfaction of the growers.

Since then, a number of co-operative societies have come into being at important cotton trading centres in the Punjab, which are either engaged in the co-operative sales of *kapas*, or lint and seed after processing, and have been able to sell the produce of the growers at a handsome premium. This system is bound to flourish provided the management possesses good business ability and is honest.

Marketing by Big Growers. The big cotton growers have large stocks of cotton and they have the capacity to withhold sales if the price structure is unfavourable. Generally, they do not bring their produce to the market, but, on the other hand, they send samples to the prospective buyers, or invite them to their godowns to examine the *kapas* in their stock. They also engage a commission agent and strike the bargain through him. The delivery of the *kapas* is taken from their godowns, and the question of *vatta* or quality allowance, or some other malpractices does not arise. The buyer is also at an advantage, because a sizeable quantity of pure stuff comes into his hand, and he can get premium for better quality. If the small growers of a village sow one variety and make efforts to maintain its purity and jointly market their *kapas* through their headman, or one of the *punches*, and invite traders to examine their stocks, they can also gain the same advantages as the big growers, and escape the difficulties confronted by them in the wholesale markets.

Agmarking of Cotton. 'Agmark' (national mark of purity) labels are fixed on the bales of lint, which conform to a certain standard of purity, i.e., at least 98 per cent. purity for 'A' class Agmark labels and 97 per cent. for 'B' class Agmark labels, and ginning of which takes place under the supervision of the Department of Agriculture. The specification also requires that the lint shall be obtained from machine-ginned *kapas*, shall be dry and free from any traces of added moisture, and that it shall be clean and reasonably free from leaf, seed, stain and other imperfections. The Agmark labels are supplied by the Marketing Adviser to the Government of India and they guarantee the quality indicated in the trade mark.

The Agmarked bales, on an average, command a premium of Rs. 3 to Rs. 4 per maund of lint in the market. A major portion of this premium is retained by the ginners, and very little is passed on to the grower. However, if the growers' co-operative societies undertake the processing of their assembled *kapas*, and their produce satisfies the specifications of Agmarking, the whole of the premium secured will go to the pockets of the growers.

GINNING OF KAPAS

Before cotton fibres can be used in spinning for making cloth, they must be removed from seeds by some kind of ginning process. In olden days, lint was removed from seed by hand, which was a very laborious and time-consuming process. Later, the following machines came into use, which are still in vogue.

1. Hand-gin
2. Power gins:
   - (*a*) Single-roller gin
   - (*b*) Double-roller gin
   - (*c*) Saw-gin

Hand-Gin. The hand-gin, '*charkha*' or '*belna*' is the oldest device and is in use in India since many centuries. Even now, in villages it is common, and domestic requirements of lint are obtained by ginning *kapas* on it. It is made of wood and has two rollers, set close to each other. The upper roller is a round iron bar and the lower is made of wood. In the older types, both the rollers are wooden. Before ginning, *kapas* is dried in the sun and opened by placing it on a loosely-woven cot and beating it with a stick. While doing so, the dried leaves and trash fall out and *kapas* gets cleaner. A woman, on an average, can gin about 14 lb. of *desi kapas* per day. The fly loss is about five per cent. Naked and semi-naked American types can also be ginned on *belna*, but fuzzy-seeded types are difficult to gin, as in their case, during the process, numerous seeds break and pass along with the lint, and the output is even less than half, i.e., about 6 lb. per day. In the villages, most of the growers, gin small quantities of their own produce of *desi kapas* with the help of *charkha*, retain lint for domestic use and the seed for sowing. The remaining *desi* and the entire American *kapas* is marketed.

Power Gins.

Single-Roller Gin : Most cotton ginning factories in the Punjab and neighbouring States are fitted with single-roller gins. The essential parts consist of a roller, covered with leather and a large knife. The knife is set so that its edge is parallel to the surface of the roller and just touches it. The *kapas* is fed by hand, and is pushed near the roller and the edge of the knife by a mechanical propeller, till it is caught there and ginned. The seeds fall on one side of the roller and the lint on the other. The ginning factories have generally two storeys. The roller gins are planted in the upper storey, in two rows facing each other. The lint falling on one side of the roller is collected in the upper storey, but the seed falling on the other side, after passing through the sieve, drops down into the lower storey.

The *kapas* brought to the factories is first graded, and heaps of different grades are prepared by the factory-owners. A good deal of yellow, stained and diseased cotton is picked from the heap by engaging female labour. It is then passed through the opener, where a considerable quantity of dust and dirt is removed and the *kapas* becomes fluffy, after which it is heaped on the platforms of machines, for ginning. The usual capacity of a single-roller gin is 1½ to 2½ maunds of *kapas* per hour, depending on the variety and the condition of the *kapas*. When the varieties of cotton to be ginned are L.S.S. and 320F or *desi*, which have semi-naked or short fuzzy or smooth seeds, the capacity per machine is higher, but it is low in the case of fuzzy-seeded varieties like 216F and H.14.

Double-Roller Gin : Double-roller gins have been installed only in a few factories. It has two leather rollers instead of one and the *kapas* for ginning is fed through a box, in between them. They are installed in two rows in the upper storey of a gin-house. The platform for heaping *kapas* for feeding is a little removed from the gins. The *kapas* is lifted from there and put in the feeding box. The lint falls on both sides; the seed dropping down in the lower chamber. The capacity of the double-roller gin is about 1½ times that of the single-roller gin. Thus, labour is saved in feeding the *kapas* to the machines. The moving knife in the double-roller gin gives such a shaking during the process of ginning, that dust and dirt are removed and the lint is comparatively cleaner. There are less chances of the seed breaking and the seed from the double-roller gin has a better appearance. The lint of the double-roller gin, on account of its cleanliness and better grade, sells at a premium of Re. 1 to Rs. 2 per maund. A double-roller gin requires better engineering skill to keep it in good working order than a single-roller gin and, consequently, more mechanical staff is required in this case, as compared to single-roller gin. One difficulty about the double-roller gin is that while *kapas* is lifted from the platform for placing it in the feeding box, some of it falls in the lint. It is, therefore always considered necessary to *jaffari* lint (separate *kapas* from lint on meshed platform) before it is stored for pressing.

The disadvantages in case of the roller gins are that the lint that comes from them is packed or waded, its appearance is not very attractive, and makes neps, which complicate spinning, and the lint contains large quantities of broken seeds, which are undesirable. These defects have been obviated in saw-gins.

Saw-Gin : The first saw-gin was installed in pre-partitioned Punjab in 1921, at Khanewal, and since then, numerous plants have been erected. With the growth of American cotton in the Punjab (India), a number of saw-gins have come into being or are under erection. A few saw-gins already exist in Ferozepur district, and others are coming up in Hissar district, where there are good prospects for the extension of area under long staple American varieties. These machines are used for ginning long staple American varieties, particularly those which have fuzzy seeds. Pure *desi* cotton is seldom ginned on these machines.

A saw-ginning machine is fitted with 70-90 disc saws, each 10 to 12 inches in diameter. These saws have slightly hooked teeth, which while rotating at a speed of 400 revolutions per minute or so, tear away fibres from the seed, which are carried away by blast or brushes. Other devices are provided to clean the *kapas* of dust, dirt, trash and other impurities, before it is actually delivered at the saws for ginning. The whole process is automatic by suction, created by the revolving of powerful fans, and connecting the passage of *kapas*, lint and seed by properly laid-out pipes. Only 1 or 2 labourers are required at the feeding tube, which takes in *kapas* by suction and transports it mechanically to the cleaner, distributor and feeders to the saws. From the saws, the seed is carried by blast or mechanical conveyers to a heap and the lint to a storage bin, where it is collected by labourers and bagged. This saves labour both at the feeding and delivery pipes of the lint. The rest of the process is automatic and clean. The lint obtained is fluffy, as if carded, clean and devoid of most of the impurities. The seed is also clean and uncut, but has slightly greater amount of fuzz on it.

The output of a saw-gin with 80 saws of 12-inch diameter varies from

15 to 20 maunds of *kapas* per hour or about ten times that of a single-roller gin.

The disadvantages of saw-ginning are that the ginning loss is higher as compared to roller gin — about 1.25 per cent. — and that there is the danger of fibre being cut by this process. However, saw-ginned lint fetches a premium of Rs. 3 to Rs. 4 per maund on account of its cleanliness and purity. In the price prescribed by the Government of India, the saw-ginned lint has been accorded a premium as shown below (Table 56).

TABLE 56. BASIC FLOOR AND CEILING PRICE FIXED PER CANDY OF INDIAN COTTON BY THE GOVERNMENT OF INDIA

Description of cotton	1952-54		1954-56	
	Floor (Rs.)	Ceiling (Rs.)	Floor (Rs.)	Ceiling (Rs.)
4F–Roller-ginned	580	850	525	850
4F–Saw-ginned	600	870	545	870
L.S.S.–Roller-ginned	640	920	685	920
L.S.S.–Saw-ginned	660	940	605	940
216F–Roller-ginned	730	1,045	675	1,045
216F–Saw-ginned	760	1,075	705	1,075

The lowest premium fixed for saw-ginned cotton is Rs. 20 per candy but in the case of quality cotton, like 216F, it is ten rupees higher.

Delinting Machines. These machines have the same principle as the saw-gins. It consists of a series of five circular saws, set close together on a rapidly revolving shaft. At the back of these saws, runs a cylindrical brush, which catches the fibres and passes them on to a reel at the back. The fibres are collected on the reel into a compact feet. As already mentioned, the saw-ginned seeds carry on them a little more quantity of lint or fuzz as compared to roller-ginned seed, with the result that it sells in the market at a discount of Rs. 1.50 or more per maund. To remove this disability, delinting machines are installed in the saw-ginning factories. An ordinary delinting machine has the capacity of dealing with 100 maunds of seed in a day, which yields, on an average, about two maunds of linters. The cost of delinting comes to Re. 1 per maund and the delinted seeds sell at a premium of Rs. 1·50 per maund. The difference partly covers the loss in ginning percentage occurring in cases of saw-ginning. The linters have also a commercial value and fetch a reasonable price.

Baling of Cotton. The entire American cotton and greater bulk of *desi* cotton, after ginning, is pressed into bales for transport to the mills or exporting centres. For this purpose, hydraulic presses, worked by steam or electricity, are generally used. In northern India, most of the ginning factories have their own pressing, but a few get their cotton pressed in other factories. Cotton ginned in rural areas, and also in the small gin houses, finds its way to the big factories or presses installed in the towns.

Roller-ginned cotton presents no difficulty in pressing but the saw-ginned lint is rather difficult to press, as it is fluffy and more voluminous. It is filled in *boras,* as it comes from the saw-gin and is allowed to stay for 24 hours. The ground on which *boras* are stacked singly is watered and water is also sprinkled outside on the hessian. It then becomes manageable and is pressed, but the net weight of lint in saw-ginned bale is less. It is only 372 lb. as against 392 lb. of roller-ginned bale. The other characteristics of the bales are as under :

Gross weight (Roller-ginned)	400 lb.
Gross weight (Saw-ginned)	380 lb.
Dimensions	48″ x 18″ x 18″
Density :	
Roller-ginned	44 lb. per cubic foot
Saw-ginned	41 lb. per cubic foot
Weight of hoops and hessian	7-8 lb.
Net weight of lint in bale :	
Saw-ginned	372 lb.
Roller-ginned	392 lb.

Cost of Ginning and Pressing. The cost of ginning in different parts of the country varies from Rs. 8 to Rs. 15 per bale and that of pressing from Rs. 10 to Rs. 12.50 per bale. The combined rate was from Rs. 19 to Rs. 25. Before the war, the ginning and pressing charges came to about Rs. 6. During 1951, an enquiry was made in different factories situated in important cotton-growing centres of the Punjab. The details of cost are given below (Table 57).

TABLE 57. COST OF GINNING AND PRESSING PER BALE AS REPORTED BY DIFFERENT FACTORIES IN THE PUNJAB

Item of expenditure	Abohar I	Abohar II	Fazilka	Tarn Taran	Khanna	Hansi I	Hansi II
Baling hoops	2·14	2·14	2·19	3·50	2·31	3·00	2·50
Hessian	2·85	2·81	2·88	3·00	2·88	3·12	2·25
Coal	2·75	2·75	2·75	3·75	2·37	4·00	3·00
Establishment	2·50	4·75	4·50	3·50	5·00	6·00	3·00
Labour	2.44	2·40	2·37	2·69	3·75	4·25	3·37
Leather	1·37	1·50	1·80	1·75	1·50	2·00	1·50
Lubricating oil	1·12	0·94	0·88	1·12	1·00	1·00	1·00
Miscellaneous	5·50	5·81	2·94	2·25	2·75	11·03	7·06
Total	20·67	23·10	20·31	21·56	21·56	34·40	23·68

In view of the wide variations in the figures of expenditure reported by different ginning factories, the actual costs of ginning and pressing were worked out separately. For making calculations, it was assumed that a factory has 40 single-roller gins, a press, a turn-out of 5,000 bales and a working season of 120 days.

COST OF GINNING AND PRESSING COMBINED PER BALES

	Rs. nP.
Salary of staff (Total expediture during the season being Rs. 17,050)	3.37
Coal	2.82
Baling hoops	2.44
Hessian cloth	2.88
Labour	2.50
Lubricating oil	1.00
Leather stores	1.37
Stores	1.25
Miscellaneous	3.08
Total	20.71

COST OF PRESSING ALONE PER BALE

Salray of staff (1/5th of the cost of establishment maintained in the factory)	0.69
Coal	0.39
Baling hoops	2.44
Hessian	2.88
Labour	0.75
Leather	0.06
Oil	0.12
Stores	0.12
Miscellaneous	1.08
Total	8.53

As already mentioned, the ginning capacity of roller-gin varies with the type of cotton to be ginned, whether it is *desi* or American, and in the case of the latter, if its seeds are naked or fuzzy. In tracts where the fuzzy-seeded cotton varieties are under cultivation, the cost of ginning is bound to be higher than calculated above.

As against the above, the Punjab Government fixed ginning and pressing charges for all the factories in the State at Rs. 19.37 for the cotton seasons 1955-56 and 1956-57. In parts of the State, where naked seeded varieties like 320F and L.S.S. are prevalent, the ginning factories have undertaken to gin and press cotton of other parties at these rates.

Pooling System. Sometimes, the ginning and pressing factories form a pool under the plea that the capacity of ginning and pressing factories in a particular locality is far in excess of the requirements, and it is not economical for all the factories to work during the season. Under this system only a few factories of the total in a locality work during the season and pay a particular fixed sum per bale into a common pool, which is divided amongst all the factories, according to their ginning capacity, at the end of the season. In this way, working as well as the silent factories earn normal profit. As a matter of fact, the pool is used by the factory-owners to eliminate competition and buy *kapas* from the growers at a reduced rate, and make unduly high profits, by keeping a wide margin. The pooling factories charge very high rates for ginning and pressing from other parties operating in the market. They too are, thus unable to give a due share to the growers, who are usually the sufferers in a pooling area. It is a healthy feature, if pooling is undertaken with a view to reducing cost, but in order to prevent the tenderer paying less to the grower, reasonable rates of ginning and pressing should be fixed and it should be made obligatory on the factories to gin and press the *kapas* of other merchant operators in the markets.

Malpractices in Ginning. Several malpractices in connection with the ginning and pressing of cotton are common in the ginning factories. Inferior varieties of cotton are mixed with superior ones at the time of ginning. Sometimes, the factory-owners adjust their ginning machines in such a way that a portion of seed is cut and is passed on with lint. This is obviously done to increase the weight of lint, which is several times more valuable than seed. Lint is also moistened sometimes. It is said that, by moistening, lint becomes soft, gains in length and strength and is amenable to easy pressing. True, but, by moistening, colour and quality deteriorate. As a matter of fact, moistening is done to increase the weight of lint and gain thereby.

IMPROVED VARIETIES

The value of a cotton variety depends upon its yielding capacity and quality. As these two characteristics are often negatively correlated, an acceptable combination of the two to give a maximum economic return under a specific set of conditions, determine the suitability of a variety. No doubt yield can be greatly increased by better farming methods and by means of increased doses of fertilisers and manures, but these factors add to the cost of cultivation. On the other hand, the adoption of a suitable variety gives profitable returns without additional expense. As a matter of fact, the success of a cotton crop depends more on the variety chosen than on any other single factor affecting yield and quality. An example will clear this point. In the southern part of Rajasthan, which is the nearest cotton-growing tract to the Northern Region, the *hirsutum* variety Indore 1 is popular and is being raised there successfully. When grown under the Punjab conditions, however, it makes good vegetative growth, but comes into reproduction late in the season, at a time when the conditions are not favourable, resulting in very poor yield. Similarly when the Punjab varieties are grown in southern Rajasthan, they break down in pest resistance and do not give remunerative return. The selection of suitable varieties of cotton for specific climatic and soil conditions and tracts is, therefore, essential for the success of this crop.

IMPROVED VARIETIES OF COTTON IN THE JOINT PUNJAB

The work of crop improvement in the Northern Region dates back to 1904, when the post of an economic botanist was sanctioned jointly for Uttar Pradesh and the Punjab. The isolation of improved strains of *desi* and American varieties of cotton was started in the joint Punjab in 1906 on a regular footing. Soon afterward, a variety named 4F was selected from acclimatized Upland Georgian cotton at Lyallpur and given out for distribution in 1914. As there was an appreciable margin of difference in price in favour of 4F against *desi* cotton, there was rapid extension of area under the former variety. The 4F plant is monopodial and bushy in nature. The number of primary sympodial branches is few. However, numerous small, secondary sympodia arise on vegetative branches, bearing of fruit being mostly at the top ends. It is late-maturing in habit with a life duration of 8½ months. Its mean fibre length is 0.78″; ginning outturn 32 per cent. and spinning value 18's to 20's counts. This medium-stapled variety remained the commercial cotton of the province for a long time and, even as late as 1940, it occupied an area of five lakh acres in the united Punjab, when many superior strains had appeared in the field. Afterwards, the area under it dwindled and at this stage it is grown only in stray and isolated pockets of the Indian Punjab.

Another strain named 289F, which was also selected at Lyallpur, from a stock originally emanating from New Orleans; acclimatized at Dharwar and later on transferred to the Punjab, was given out for distribution in 1921. It became popular in the South-western districts of the Punjab and was also successfully grown in Sind. It was semi-bushy and medium sympodial in habit, with dark green and very big leaves. It possessed superior lint, having the mean fibre length of 0.97″, capable of spinning 40's counts. Its life duration was eight months. Its chief drawback was its low ginning outturn (28 per cent.) due to which it was not popular with the ginners and could not stand competition with other improved varieties that soon appeared on the scene. This variety as such, therefore, could not exist for long. However, it formed a good base for the future improved strains.

In order to give a fillip to the cotton improvement and development work, the "Punjab Botanical Scheme" was started in 1925, under the financial patronage of the Indian Central Cotton Committee. Later on a number of other schemes came into operation as branches of the main scheme to solve the local problems of various tracts in the canal colonies. Selection and reselection from the new introductions and established strains continued to be the main channel of work. A robust, healthy, vigorous growing plant, with fluffy and good opened bolls, selected in 1928 at Lyallpur, from a field of 4F, suffering from 'bad opening', bred true and laid the foundation of a very successful variety L.S.S., named after the worker, who made the original selection. This variety was released for distribution in 1933 and became very popular in the central canal colonies of the joint Punjab.

In fact, this was the only improved variety of American cotton out of half a dozen evolved in the joint Punjab that was being grown on a very limited area in the Ferozepur district of the East Punjab at the time of partition. The plant of L.S.S. is bushy, vigorous growing and monopodial in habit. Often 20 well-developed monopodia have been counted. Very few sympodia arise on the main stem, but secondary short sympodial branches are numerous and are borne on the monopodia. It is very late-maturing in habit and possesses the life duration of nine months. The leaves have a characteristic pale green colour and the bolls are small in size (Plate II). It possesses a high yielding capacity; its mean fibre length is 0.88″; ginning outturn 32 per cent. and it has spinning value of 33's counts. In the truncated Punjab, during 1950-51, it covered an area of 1,88,000 acres, i.e., 26.3 per cent. of the total cotton acreage of the State; but at present the area under it has greatly declined as varieties more suitable than this and better in quality have been evolved, which have rapidly replaced it. The L.S.S. variety is now confined to one corner of the Ferozepur district (Fazilka sub-division), where water supply is liberal and suits its late-maturing habit better.

The next improved strain to be evolved was 289F/43 by selection from the original stock allied to 289F. It was originally selected in Lyallpur in 1925 and was approved for distribution in 1934. The outstanding characteristic of this variety was its early-maturing habit. The previously mentioned varieties gave first picking by the middle of November, whereas, 289F/43 was ready for first picking by the middle of October. Its life duration was also comparatively shorter, due to which it was tolerant to water shortage. The plant of 289F/43 was conical in shape; had an erect main stem; low sympodial habit and three to four well-developed monopodia at the base. Sympodia were long and trailing; sometimes five to six nodes in length and mostly borne on the main stem. It had big bolls and was tolerant to jassid. Its mean fibre length was 0.96″, with a ginning outturn of 29 per cent. and spinning value of 36's counts. It spread in the South-western districts of the Punjab but had the drawback of having a low ginning percentage.

Another variety, 289F/K25, was developed at the British Cotton Growing Association Farm, Khanewal. Because of the tall size of its plants, it was called *ghora narma.* It was early-maturing in habit and resembled 289F/43 in this respect. The plants were erect and sympodial in habit with hardly four to five good-sized monopodia at the base. It had dark green leaves and big bolls. Its mean fibre length was 0.89″; ginning outturn 34 per cent. and spinning value 38's counts. It was highly susceptible to jassid, and remained localised in Khanewal Sub-division of Multan district, where, because of extreme arid conditions, jassid was not a serious pest. Its high ginning outturn was its chief asset and together with 289F/43 it occupied an area of eight lakh acres during 1943-44.

Still another improved strain evolved was 289F/124 (Afzal and Avtar Singh, 1942). It was developed from 289F at the Cotton Breeding Sub-station, Multan; approved for distribution in 1945 and was named 'Victory', because of its release in the year of the successful termination of the Second World War. Its plant was erect-growing; had six to seven fair-sized monopodia and its leaves were dark green with big bolls. It was the earliest maturing of all the foregoing varieties and was ready for first picking by the beginning of October. It was very prolific and combined in it the good properties of long lint (mean fibre length 0.95″); high ginning percentage (33.5 per cent.) and desirable spinning value (40's counts). By the time this variety was officially released for distribution in 1945, it had spread of its own accord on several lakh acres, in the south-western districts of the Punjab, and thereafter entirely replaced 289F/K25 and 289F/43 in the tract during the subsequent years.

However, the climax in the cotton improvement work in the pre-partition period was the production of the variety 199F. It was later renamed 'Sultani'. It was developed at the Cotton Breeding Sub-station, Multan, from a natural cross plant occuring in a progeny of 4F, imported from Sakrand (Sind, Pakistan). It was placed on the Departmental list of approved seeds in 1946. The plant of 199F was semi-bushy in habit with eight to nine fairly developed monopodia. It was medium to early in maturity, with big-sized bolls and a fluffy good opening. The leaves and stems were covered with a thick coating of hair, which imparted to it an extraordinary resistance against jassid (Afzal and Ghani, 1945). It possessed a rare combination of high yield, long lint (0.97″) and a very high ginning percentage (37.5). Because of these qualities, it commanded a good premium over the other varieties of cotton and was claimed to be one of the best American cotton strains evolved in India.

A few varieties of *desi* cotton had also been evolved; '119 Sanguineum' (Afzal and Avtar Singh, 1941) for the South-western tract of the Punjab; '39 Mollisoni' for canal colonies and central districts and 'M.60-A.2' for the South-eastern districts. These types suited their respective zones from the point of view of yield, but in quality there was nothing to choose between them, as all of them were low in spinning value (6's counts). Another series of *desi* cotton strains, called 'Jubilee' cotton, derived from a cross of 39 Mollisoni of the Punjab and Million Dollar of China was developed. In the initial stages these types appeared promising, because of their superior lint quality (spinning value 15's to 18's counts) and high ginning outturn (36 to 37 per cent.) but could not become popular because of a comparatively lower yielding capacity.

With the partition of the Punjab, the tract growing *desi* variety M.60-A.2 (South-eastern districts), a portion of the tract of 39 Mollisoni (part of central districts) and a small area growing about 40 thousand acres of American variety L.S.S. in Ferozepur district came to the share of the Indian Punjab, and all the aforesaid excellent varieties of American cotton, and their respective tracts went to the share of Pakistan.

DEVELOPMENT OF IMPROVED VARIETIES OF COTTON IN PUNJAB (INDIA) DURING POST-PARTITIONED PERIOD

As stated before, with the partition of the Punjab, practically the entire American cotton-growing area was sliced away and a little more than one-fourth of the total cotton area that came to the share of the Indian Punjab was growing only short-stapled *desi* cotton. Fortunately, at that time two cotton breeding sub-stations were functioning in East Punjab for producing better varieties of *desi* cotton. But as the supply position of long-linted superior cotton in the country was precarious and they were keenly in demand by the textile mills, the work of the sub-stations was geared to the evolution of long-linted varieties of American cotton. Soon the results were achieved and the following four outstanding varieties were produced.

Punjab-American 216F. This variety was the first to be given out after partition and was released for distribution in 1948, for the South-eastern tract of the Punjab, where previously short-stapled *desi* variety M.60-A.2 was under general cultivation. The success of P.A. 216F was due to its extreme early-maturing habit, and its ability to thrive under water shortage conditions. Due to the former trait, it completed its life cycle in 6½ months and gave most of its produce before the commencement of the incidence of pink bollworm, which is a usual feature in the tract and in certain years its infestation does great damage to the cotton crop; and by virtue of the latter trait it fitted in well with the water scarcity conditions prevalent here, viz., availability of canal water by rotation for only 10 days during a month (Sikka and Avtar Singh, 1951).

The variety P.A. 216F is a reselection from M.4, which at one time was popular in Sind. The plant of 216F has erect habit; attains a height of four to five feet under normal irrigated conditions; develops one to three monopodia at the base and the fruiting branches are borne from ninth node upward. It has broad and dark green leaves with a thick coating of hair, which makes it fairly resistant to jassid (*Empoasca devastans*). The bolls are fairly large with 4 to 5 loculii. The seeds are big in size with a dirty-white fuzz on them (Plate III). The first picking is ready by the middle of September and the crop is over by the middle of November.

In yield and other economic characters 216F is far superior to the standard *desi* variety Mollisoni 60-A.2, which is an improved *desi* variety for this tract. The comparison of the economic characters of P.A. 216F and M.60-A.2 is shown in Table 58.

TABLE 58. COMPARISON OF ECONOMIC CHARACTERS OF 216F AND M.60-A.2

Character	216F	M.60-A.2
Yield of *kapas* per acre (mds.) (average of 63 replicated trials)	13·74	12·15
Mean fibre length (inches)	0·93	0·67
Ginning percentage	33·3	38·7
Mean fibre weight per inch ($\times 10^{-6}$ oz.)	0·151	0·291
Percentage blow-room loss	10·5	10·1
Percentage card-room loss	7·1	7·4
Highest standard warp counts	33's	6's

The data show that the yielding capacity of 216F is 13 per cent. higher; its lint is far superior in length, fineness and spinning value than M.60-A.2. In ginning percentage 216F is lower, but this difference is expected as the Punjab *arboreums* as a group are higher ginners than *hirsutums*. Due to superior lint quality 216F invariably gave a higher cash return per acre. Data collected at Hansi for five years (1948-1952) on this aspect are summarised in Table 59 (Negi and Avtar Singh, 1956a).

TABLE 59. COMPARATIVE CASH RETURN PER ACRE OF 216F AND M.60-A.2 AT HANSI (AVERAGE OF 1948-52)

Particulars	Comparative value for		Excess over M.60-A.2
	216F	M.60-A.2	
Yield of *kapas* per acre (mds.)	17·77	14·84	2·93
Yield of lint per acre (mds.)	5·86	5·72	0·14
Yield of seed per acre (mds.)	11·91	9·12	2·79
Cash return per acre (Rs.)	870	455	415

The P.A. 216F gave almost a double cash return per acre as compared to M.60-A.2 which was mainly due to the higher price it fetched on account of superior lint.

As the growing of 216F was highly remunerative, the growers readily took up its cultivation and it rapidly began to replace *desi* Mollisoni 60-A.2 (Avtar Singh and Panwar, 1953). By 1954, i.e., six years after its release, it covered an area of 1,34,000 acres (69 per cent. of the cotton area of the South-eastern districts); converting a short staple cotton area into a long staple American cotton growing tract.

The P.A. 216F has also spread to the adjoining State of Uttar Pradesh, where it has become popular with the growers. On account of its short life duration, it has been found suitable for growing in rice fallow lands in Madras State (Kalyanaraman and Rangaswami, 1955), where, by its adoption, cotton has come to be grown on land which otherwise would have remained fallow during winter and would have produced nothing. Experiments on the suitability of 216F for such purposes are also under way in the States of Andhra and Mysore. Successful growing of 216F as a regular crop has recently been reported from Bihar as well (Singh, 1956).

Punjab-American 320F. The next improved variety evolved after partition was the Punjab-American 320F. It was approved for distribution in 1951, originally for the central districts of the Punjab for replacing *desi* cotton, but because of its early-maturing habit and tolerance to shortage of water, it spread to Ferozepur district, from where it ousted L.S.S. (the previous improved American variety) from 57 per cent. of the area under American cotton.

The variety 320F is a straight selection from L.S.S. but it is quite distinct in character from the parent variety. It is erect-growing in nature as against the bushy habit of L.S.S. The plant attains a height of 5 to 5½ feet under normal irrigated conditions and has 3 to 6 monopodial and 10 to 14 sympodial branches as against 8 to 13 monopodial and 8 to 10 sympodial branches in L.S.S. The leaves have deep green colour, whereas the leaves of L.S.S. are pale green. Because of dense coating of hair on the underside of the leaves and stems, the plant is able to resist to a high degree the attack of jassid (*Empoasca devastans*). The bolls are four to five locked, whereas those of L.S.S. are mostly four locked. The crop of 320F is ready for first picking by the end of September and the entire crop is over by early December, whereas, in the case of L.S.S. last picking time extends to early January. The opening of bolls in 320F is good and fluffy. The bulk *kapas* of 320F has a dull white appearance, as against bluish white appearance of L.S.S. *kapas*. The seeds are light fuzzy to semi-naked (Plate IV). On the other hand, the seeds of L.S.S. are uniformly semi-naked (Negi and Sehgal, 1957).

Extensive trials have been conducted to assess the yielding capacity of 320F against *desi* cotton in central districts of the Punjab, and against L.S.S. in Ferozepur district; the results of these trials, together with mean fibre properties of these varieties are summarised in Table 60.

TABLE 60. COMPARISON OF ECONOMIC CHARACTERS OF P.A. 320F and L.S.S.

Particulars	320F	L.S.S.	Remarks
Yield of *kapas* per acre (mds.) (mean of trials conducted in central districts)	16·46	13·56	Comparison is with *desi* cotton
Yield of *kapas* per acre (mds.) (mean of trials conducted in Ferozepur district)	19·16	17·67	Average of 7 years trials
Ginning percentage	34·6	33·4	Average of 6 years
Mean fibre length (inches)	0·91	0·88	
Mean fibre weight per inch ($\times 10^{-6}$ oz.)	0·148	0·152	
Pressley strength index	8·4	8·1	
Highest standard warp counts	38·7	37·7	

The data show that on an average, 320F gave 2.9 maunds more *kapas*, viz., a 21 per cent. higher yield than *desi* in central districts, thus exploding the previous notion that the Punjab-American cotton could not successfully be grown in this zone. In the Ferozepur district, 320F proved its superiority by giving nine per cent. higher yield over L.S.S. Besides, the new variety was superior to the parent variety L.S.S. in all the fibre characters, such as its average ginning percentage was higher by 1.2 per cent., its lint was longer, finer and stronger resulting in high spinning value. Because of these superior qualities, the *kapas* of P.A. 320F has invariably been fetching a higher price than the *kapas* of L.S.S. and *desi*, which is indicated below in Table 61.

TABLE 61. COMPARATIVE RATES OF *Kapas* OF 320F, L.S.S. AND *Desi* (1953-56)

Year	Average rate of *kapas* (Rs.)		
	320F	L.S.S.	Desi
1953-54	37·19	36·81	28·12
1954-55	29·25	28·62	24·50
1955-56	34·56	33·56	28·75

Being a higher yielder and more valuable than the *kapas* of other varieties of cotton, P.A. 320F immediately on release gained popularity amongst the growers and began to spread with great speed. Right from the Gurdaspur district in the North, and the Sriganganagar district of Rajasthan in the South and almost in the entire tract of former Pepsu, it was acclaimed to be the most suitable variety of American cotton. The extent of its popularity can be visualised from the fact that by 1955, i.e., during a short period of five years from its release it covered 4,76,000 acres, viz., 80 per cent. of the American cotton area of the tract. In fact out of all the American cotton varieties, P.A. 320F is most popular in the Punjab, which is evident from the data presented in Table 62.

TABLE 62. AREA UNDER IMPROVED VARIETIES OF COTTON IN THE PUNJAB DURING 1957-58

Variety	Area (thousand acres)	Percentage of total cotton acreage
Punjab-American 320F	658	43·2
Punjab-American H.14	166	10·9
Punjab-American L.S.S.	98	6·4
Punjab-American 216F	68	4·5
Mollisoni and other *desi* types	532	35·0
Total	1,522	100·0

The variety 320F has covered almost double the area of all the other American improved varieties put together. This fact shows the wonderful adaptability and the wide range of conditions under which it can give satisfaction to the growers.

Punjab-American H.14. The variety Punjab-American H. 14 has been evolved at the Cotton Breeding Station, Hansi, for the South-eastern tract of the

Punjab for replacing the previous improved variety P.A. 216F, as the former is an improvement on the latter, in almost all the economic characters, viz., yield, ginning percentage and lint qualities. The original plant giving rise to this variety was selected from the bulk crop of P.A. 216F in 1947, and after preliminary testing, it was given a strain number in 1949. The strain was thoroughly tested at the departmental farms and on the fields of the growers for a period of six years, at the end of which, it was officially released for distribution in 1954 (Avtar Singh and Negi, 1954).

The plant of P.A. H.14 is vigorous in growth and erect in habit. Under normal irrigated conditions, it attains a height of four to five feet. On soils of average fertility it develops none to three monopodial branches at the base and the sympodia arise from seventh node upwards. Its leaves are dark green. Its leaves, stems and petioles are covered with more dense coating of hair than P.A. 216F. This character imparts relatively greater resistance to this variety against jassid. The bolls are big with four to five loculii; the bolls with five loculii being about 40 per cent. The opening of bolls is good and fluffy. The *kapas* of H. 14 is more fluffy, whiter and more attractive than that of P.A. 216F. The seeds are big in size and have a dirty white fuzz on them (Plate V). The crop of H.14 is ready for first picking by the middle of September and all the pickings are over by the end of October. The habit of H.14 in giving first picking early and finishing off quickly in one and a half months' time is of particular importance in avoiding a pink bollworm attack, which, in certain years, is a very formidable pest in the South-eastern tract of the Punjab.

The H.14 has been thoroughly tested for yield in regular replicated trials conducted at Hansi and other departmental farms situated in the tract against the improved strain 216F, since 1949. A summary of these trials conducted during the period 1949 to 1957 is presented in Table 63.

TABLE 63. SUMMARY OF YIELD TRIALS COMPARING P.A. H.14 AND P.A. 216F IN SOUTH-EASTERN TRACT OF THE PUNJAB

Place of trial	Average yield of *kapas* (maunds per acre)		Excess (+) or decrease (−) over standard	Remarks
	H.14	216F		
Hansi	15·74	14·28	+1·46	Average of 32 trials
Rohtak	11·05	10·37	+0·68	Average of 8 trials
Gurgaon	16·02	14·09	+1·93	Average of 7 trials
Kernal	12·80	11·04	+1·76	Average of 7 trials
Sirsa	15·10	13·72	+1·38	Average of 8 trials
Average	14·75	13·33	+1·42	Average of 62 trials

It is evident that on the average of 62 trials conducted on the departmental farms situated in the tract, H.14 gave a higher yield than 216F; the excess being 1.42 maunds of *kapas* per acre, i.e., an increase of 11 per cent.

The P.A. H.14 is superior to P.A. 216F in ginning percentage and the fibre properties as is shown in Table 64.

TABLE 64. COMPARATIVE GINNING PERCENTAGE AND FIBRE PROPERTIES OF H.14 AND 216F

Properties	H.14	216F
Ginning percentage	34·9	33·5
Mean fibre length (inches)	0·96	0·95
Mean fibre weight ($\times 10^{-6}$ oz.)	0·152	0·156
Pressley strength index	8·5	8·1
Highest standard warp counts	37's	31's

Because of its high ginning percentage, comparatively superior spinning value, attractive appearance and higher yield, P.A. H.14 has always been rated higher, and consequently it has been giving more cash return per acre than P.A. 216F. The calculated comparative cash return of the two strains for the past eight years (1949-56) is given in Table 65 (Avtar Singh and Negi, 1958).

TABLE 65. COMPARATIVE CASH RETURN PER ACRE OF H.14 AND 216F AT COTTON BREEDING STATION, HANSI

Year	H.14			216F		
	Yield (maunds per acre)		Cash return (per acre)	Yield (maunds per acre)		Cash return (per acre)
	Lint	Seed		Lint	Seed	
1949	2·91	5·31	411	2·33	4·72	325
1950	5·14	9·42	1,148	4·62	8·94	992
1951	6·27	11·40	779	5·77	11·58	709
1952	7·23	13·14	813	6·25	12·69	738
1953	8·15	14·87	899	7·43	14·69	807
1954	7·16	13·29	624	6·50	12·81	567
1955	4·97	10·28	555	4·51	9·37	516
1956	7·90	15·08	916	6·78	12·92	786
Average	6·22	11·59	768	5·52	10·97	680

On the average of the above figures P.A. H.14 gave Rs. 88 or 13 per cent. excessive income over 216F.

Ordinarily, the crop of H.14 finishes by the end of October and the field is vacated by the first week of November; the time when the season for the *rabi* sowings just starts. An acre field of H.14 cotton, from which a *kapas* yield of 11.94 maunds had been obtained, was harvested on 3rd November, 1954. Immediately after it, two major *rabi* crops, wheat and gram were sown replicated on 9th November, and manured with graded doses of nitrogen. The object was to explore the possibility of taking a *rabi* crop immediately after cotton. The results obtained are shown in Table 66 (Negi and Avtar Singh, 1956b).

Table 66. Yield of Wheat and Gram Sown Immediately After H.14 Cotton Under Graded Doses of Nitrogen

Treatment	Yield (maunds per acre)				Estimated gross income (Rs.)		Estimated net income after deducting cost of fertilizers (Rs.)	
	Wheat		Gram					
	Grain	Straw	Grain	Straw	Wheat	Gram	Wheat	Gram
Control	3·5	5·0	17·6	26·6	49	172	49	172
12 lb. N per acre	7·2	11·7	17·0	26·8	104	166	95	197
24 lb. N per acre	11·1	16·8	16·9	27·0	158	165	140	147
36 lb. N per acre	14·0	26·6	16·7	25·8	208	163	180	135
C.D. at 5 per cent.	1·35		N.S.					

Basis of calculations :

Wheat grain	Rs. 12·00 per maund
Wheat straw	Rs. 1·50 per maund
Fertilizer	Rs. 12·75 per maund
Gram	Rs. 9·00 per maund
Gram straw	Rs. 0·50 per maund

The data show that a good crop of gram can be raised after H.14 cotton without application of any fertilizer, whereas, for a successful wheat crop, judicious manuring is necessary. The earliness of H.14, therefore, is a very desirable feature, because it enables the cultivators to have two crops in a year from the same field and thereby enhances their income.

The practice of growing a *rabi* crop immediately after cotton is becoming popular. A sample survey conducted round about Hansi indicated that about 75 per cent. of the area under H.14 is cropped immediately after cotton, chiefly with gram crop, though a few cultivators grow wheat, *metha* (*Trigonella foenum graecum*) and *masur* (*Lens esculenta*). Growing of gram after cotton is a helpful practice for increasing food production as well as conservation of soil fertility.

The good qualities of H.14 are winning it popularity amongst the growers. Released officially in 1954, it spread and replaced 216F at a very rapid rate. From an area of 800 acres under it in 1954, it covered an area of 1,65,000 acres during 1957-58 (i.e., replaced 42 per cent. of the total area under *desi* and American varieties in the tract).

It has begun to do well in other States as well. In Uttar Pradesh there is a growing demand for its seed. It has been found to be more suitable in yield and fibre qualities than the other American varieties for growing in the rice fallow lands of Mysore State (Srinivasa Iyengar *et al.*, 1957).

It has already been shown that an additional income of Rs. 88 per acre accrues to the growers of P.A. H.14. As growing of gram after it is becoming common, an income of Rs. 50 will be derived from this crop also. Thus the growers of H.14 would earn an extra income of about Rs. 128 per acre, which will go a long way in improving their economic condition.

Punjab-American LL.54. The variety Punjab-American LL.54 has been evolved very recently at the Cotton Breeding Station, Abohar, and is expected to flourish in the South-western zone of the region comprising the districts of Ferozepur and Bhatinda of the Punjab and the Sriganganagar district of Rajasthan. The special feature is its extra-long lint of 1.07 inches. Cottons with lint length over one inch are deficient in the country, and about six lakh bales of such cottons are imported from abroad, principally from Egypt, the Sudan, East Africa and the United States at a huge cost of 50 crores of rupees every year. In order to bring about their self-sufficiency, a few breeding schemes were piloted by the Indian Central Cotton Committee with the aid of the State Governments in the important cotton-growing regions. One of the schemes was started at Abohar, in the Punjab, in 1949. As a result of the work done during the past nine years, the variety LL.54 was released for distribution in 1958 (Plate VI).

The variety LL.54 is hybrid in origin, having been synthesised from a cross of two Punjab-American strains 45F and L.S.S. The cross was originally made at Lyallpur with a view to combining early-maturing habit of 45F with high yielding capacity and the jassid resistance of L.S.S. As both the parent varieties employed possessed lint length below one inch, an improvement of this character was not in view then. Most probably due to the action of additive genes for lint length, the derivative progenies of this cross, were found to be superior in lint length as compared to both the parents involved. Some material from this cross was transferred to East Punjab at the time of partition. Its systematic and careful study resulted in the evolution of LL.54

The characteristic morphological features of LL.54, which distinguish it from other American types are its dark green colour of leaves with coarse and rough texture; dense foliage; short stature and spreading nature of the plant. Its leaves, petioles and stems are covered with hair, which impart to it a moderate resistance to jassid. Its bolls are big in size, which open with a nice fluff. The seeds are big and are partially covered with a dirty white fuzz.

The variety LL.54 has been extensively tested for yield, against 320F, the standard variety of the tract at the cotton research station, Abohar (Ferozepur district); and on the land of the cultivators in regular replicated trials, since 1953. A summary of the results of the trials and other important features of the new variety are given in Table 67 (Negi and Aujla, 1958).

The data indicate that type LL.54 on an average gave about a maund extra yield of *kapas* per acre than P.A. 320F. It is far superior in lint length; has considerably finer fibres; possesses 2.5 per cent. higher ginning out turn, and spins 10 counts more than 320F. On account of these extraordinary qualities its lint commanded considerable premium, with the result that it

TABLE 67. COMPARISON OF LL.54 AND 320F IN FEROZEPUR DISTRICT (1953-57)

Particulars	LL.54	320F
Yield of *kapas* per acre (mds.)		
(*a*) Cotton Research Station, Abohar	* 20·97	19·0
(*b*) Cultivator's land	** 15·2	14·1
Mean fibre length (inches)	1·07	0·90
Mean fibre weight ($\times 10^{-6}$oz.)	0·119	0·149
Pressley strength index	8·4	8·2
Spinning value	48	38
Ginning percentage	36·2	33·7
Cash return per acre (Rs.)	681·0	534·0

*Average of 5 trials conducted from 1953 to 1957

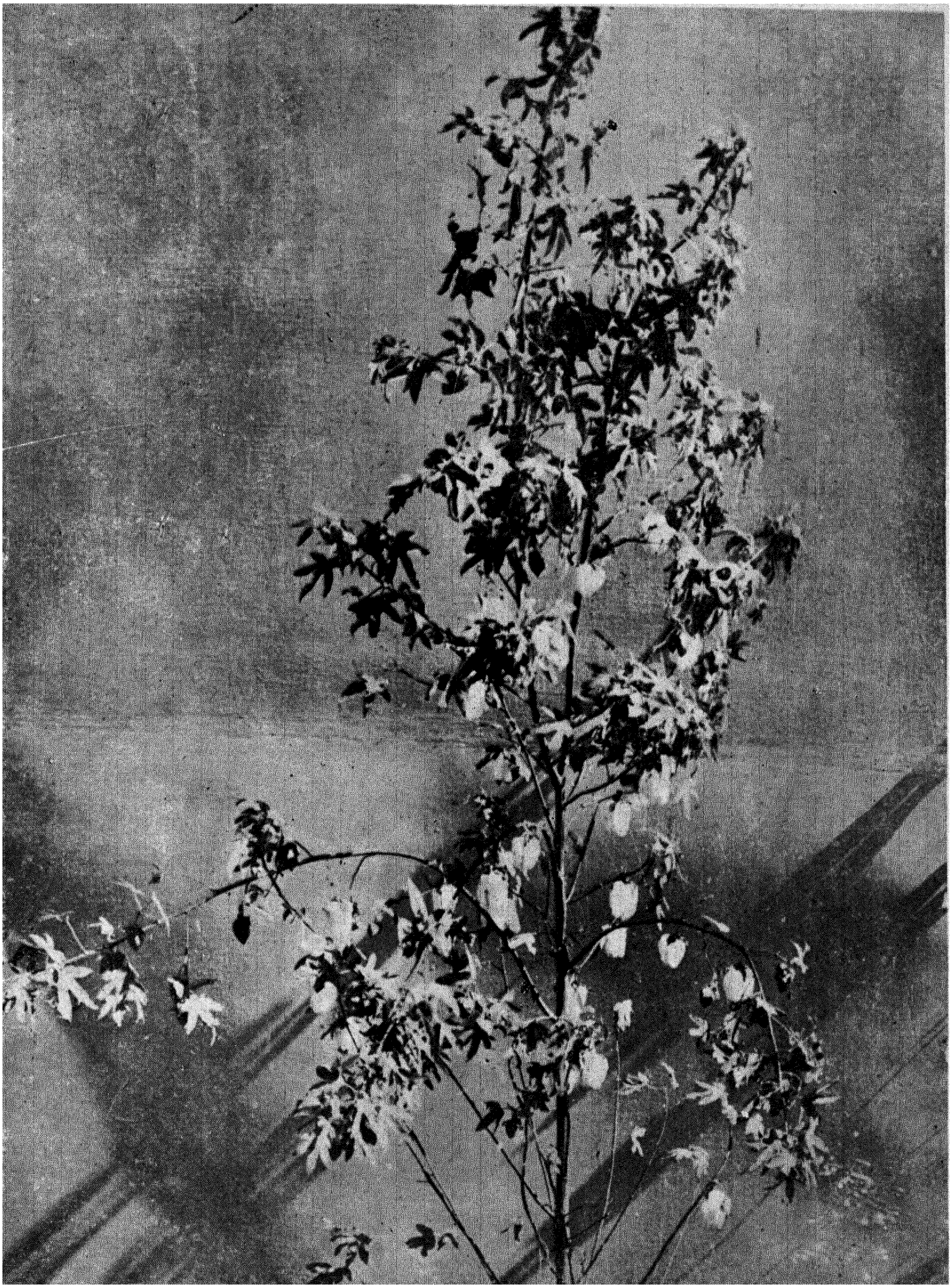
**Average of 46 trials conducted from 1953 to 1957

gave a very decent extra income per acre to the growers. As LL.54 is of the same order in early-maturing habit as 320F, there is every reason to believe that the new variety will become very popular in the near future and replace 320F on a wide scale in South-western zone of the region. When LL.54 goes into full production it will fulfil the long standing need of the textile mill industry by meeting their demand of cotton of one inch and above staple to sufficient extent from within the country and consequently there will be considerable saving in foreign exchange and greater prosperity to the peasants of the Ferozepur and Bhatinda districts of the Punjab and the Sriganganagar district of Rajasthan.

IMPROVED VARIETIES OF COTTON IN UTTAR PRADESH

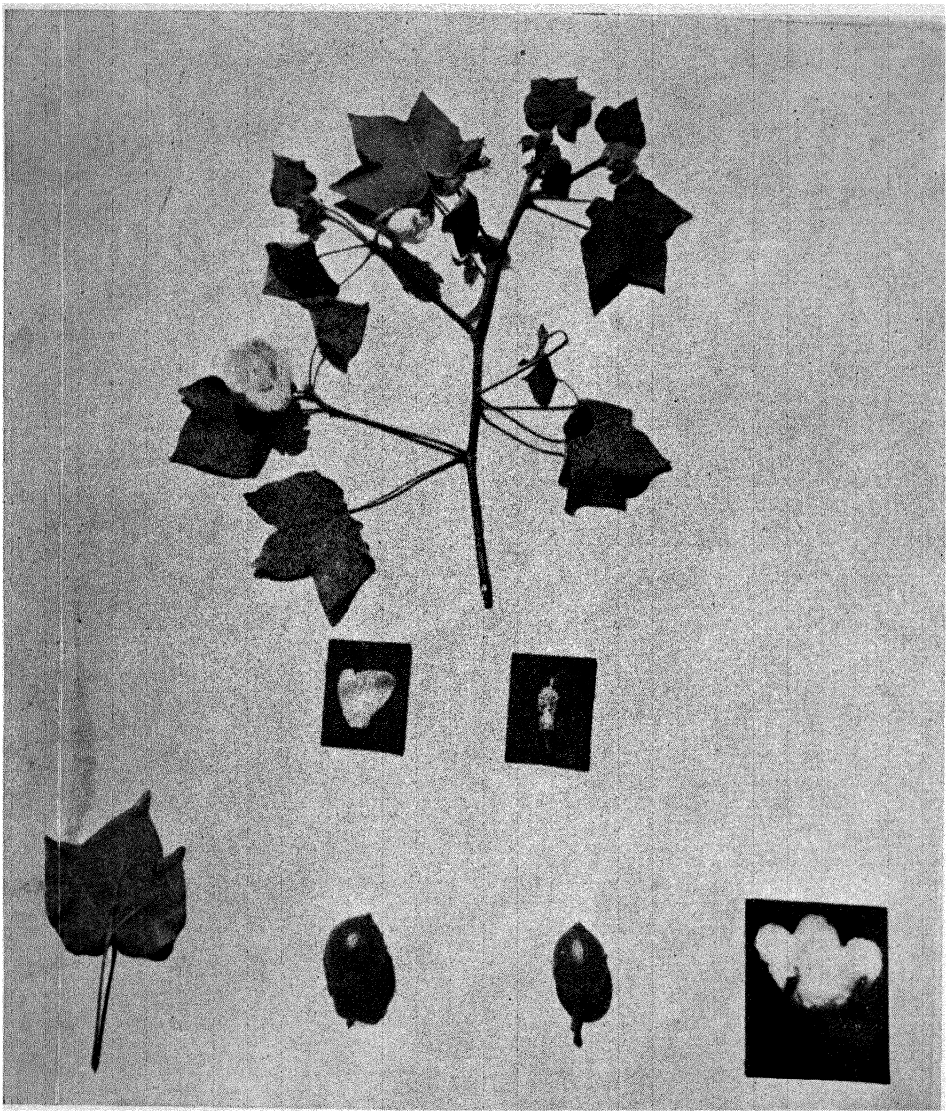
About a decade and a half back the *arboreum* variety C.520 originally selected from indigenous material of the Saharanpur district was grown in most of the cotton-growing tracts of Uttar Pradesh. It had narrow-lobed leaves, small white flowers, with dark eye; was a high yielder, possessed good ginning out turn and was capable of spinning 11 to 12 counts. Its cultivation was encouraged by Delhi and Uttar Pradesh mills, as its spinning performance was much better than the Punjab *desi* cotton which they used to import, and whose spinning was hardly six to eight counts. In due course of time another variety, namely 35/1, was developed, which being superior in yield and quality practically ousted C.520.

While attempting to grow American cotton in Uttar Pradesh some material was imported from Persia. A selection from it gave rise to the variety Perso-American. Vigorous efforts were made by the State Agricultural Department for its successful cultivation, but being somewhat late in maturity, it suffered seriously from the incidence of pink bollworm, which not only reduced its yield considerably but also spoiled its quality. In order to save the crop from the menace of this pest, the State Government enacted legislation to make it compulsory for cotton seeds, meant for sowing, to be

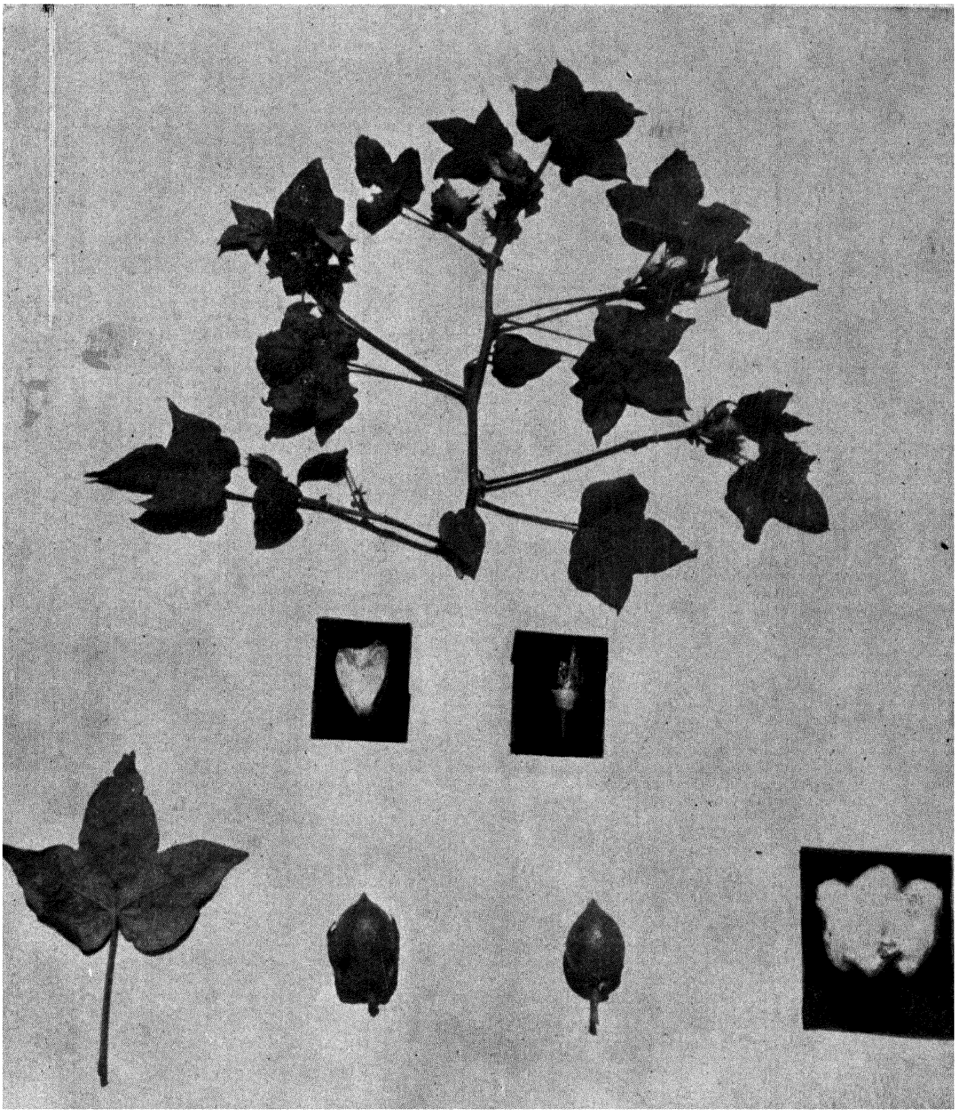


Typical 231R Cotton Plant

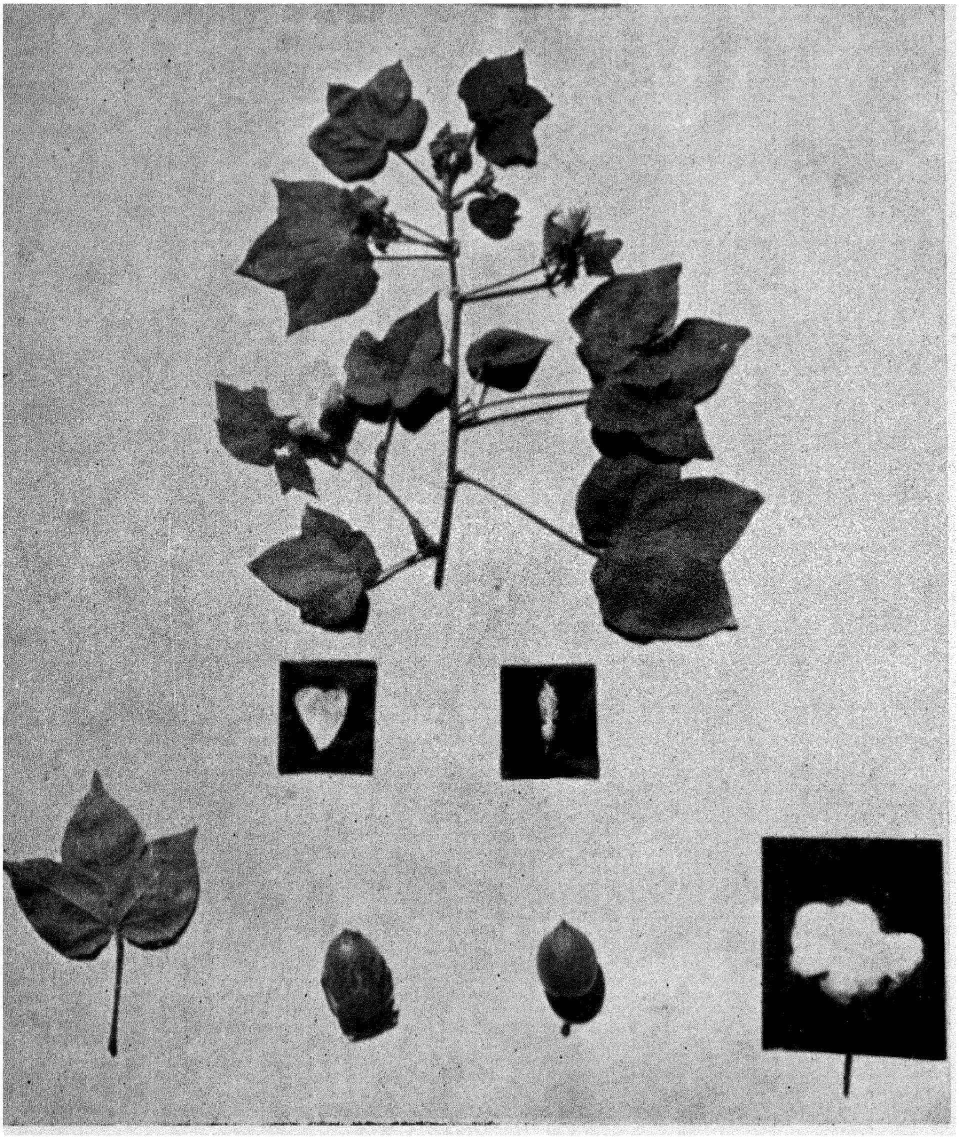
PLATE II



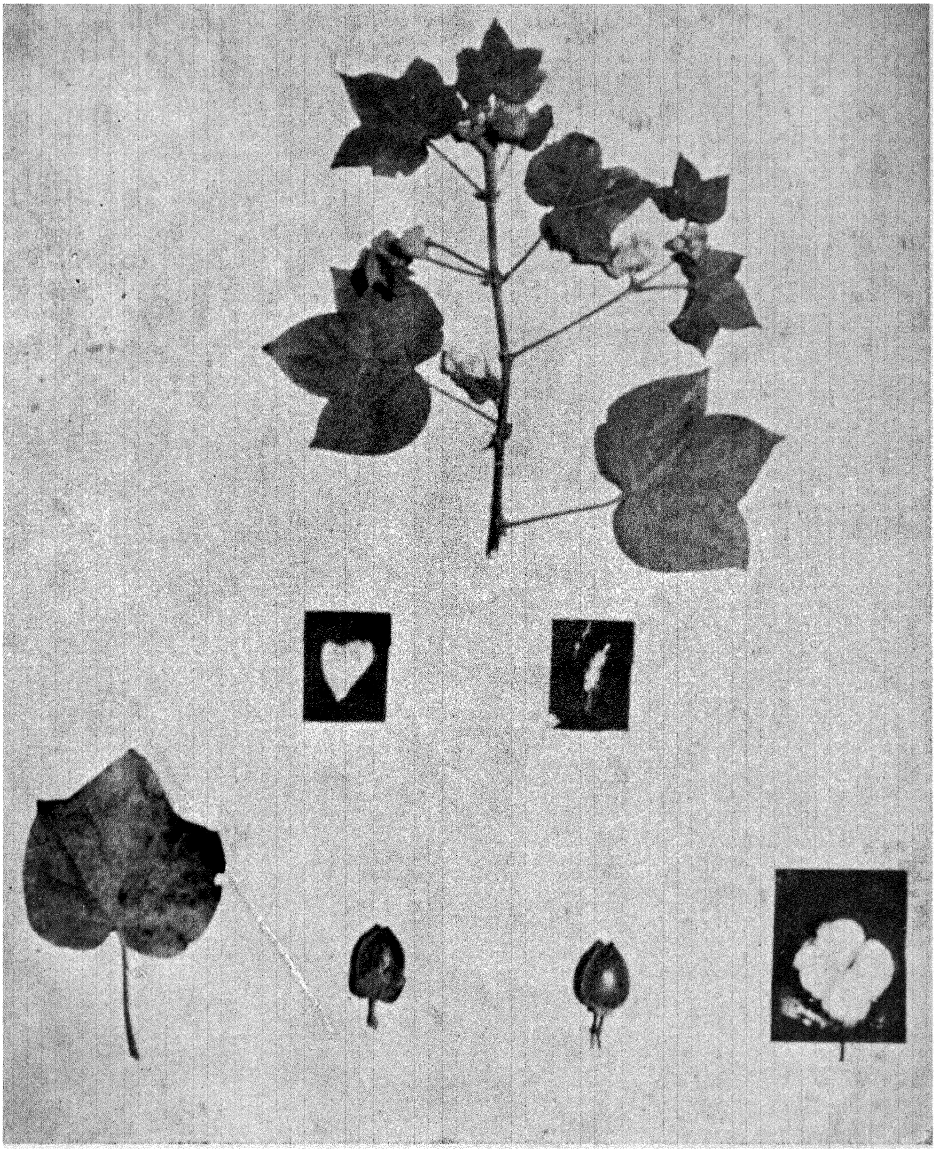
Characteristics of L.S.S. Cotton Plant



Characteristics of 216F Cotton Plant

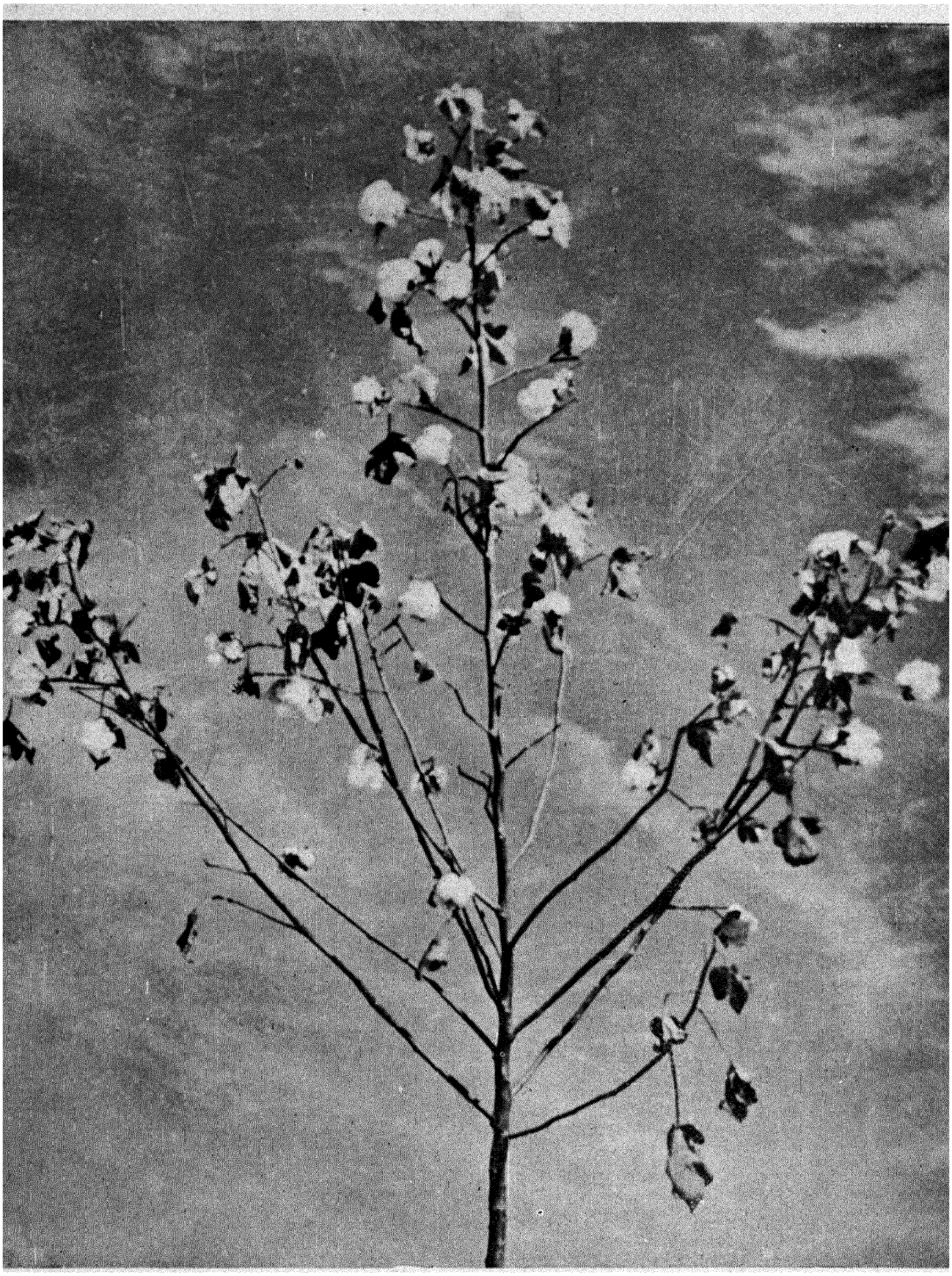


Characteristics of 320F Cotton Plant

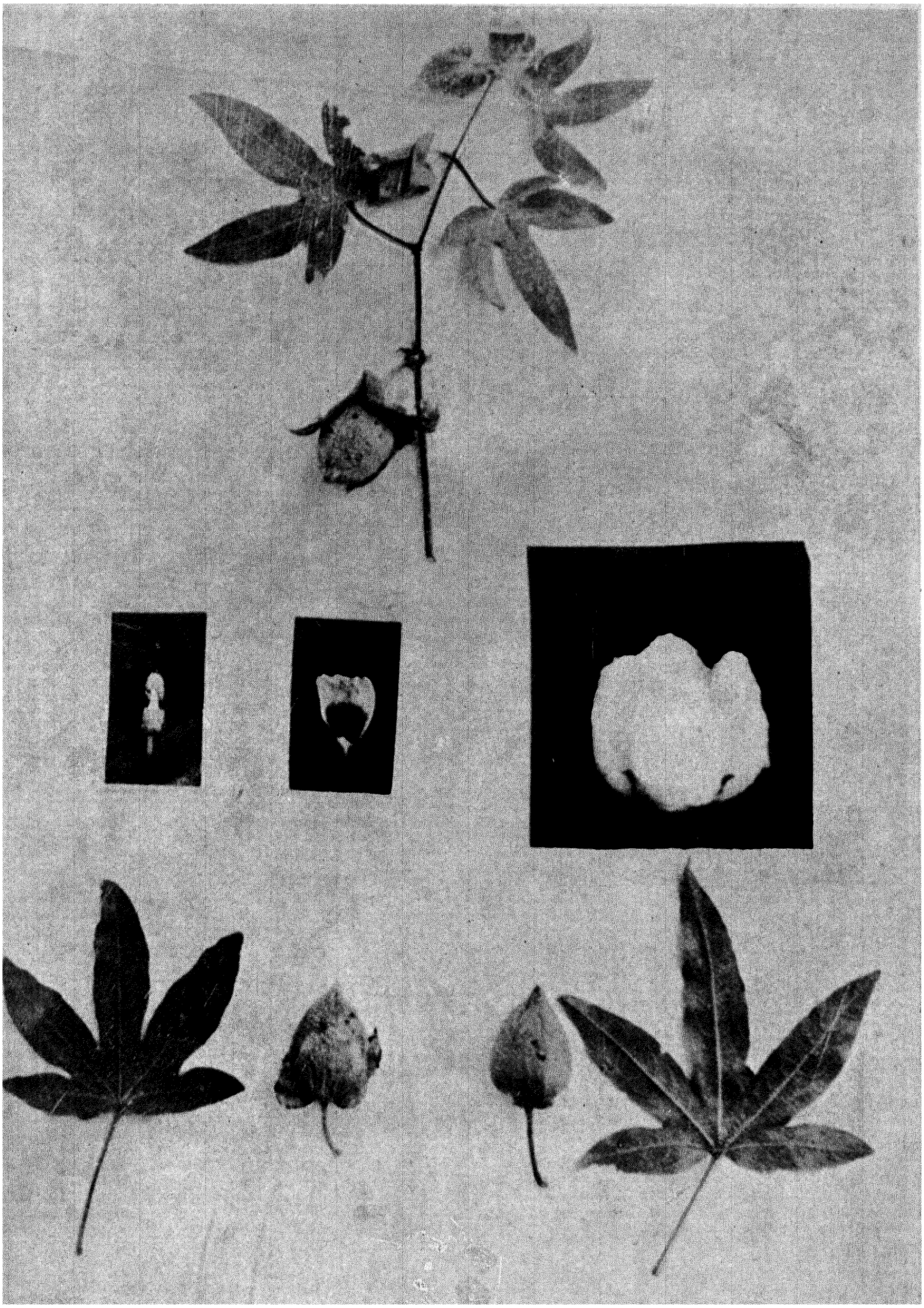


Characteristics of H.14 Cotton Plant

PLATE VI

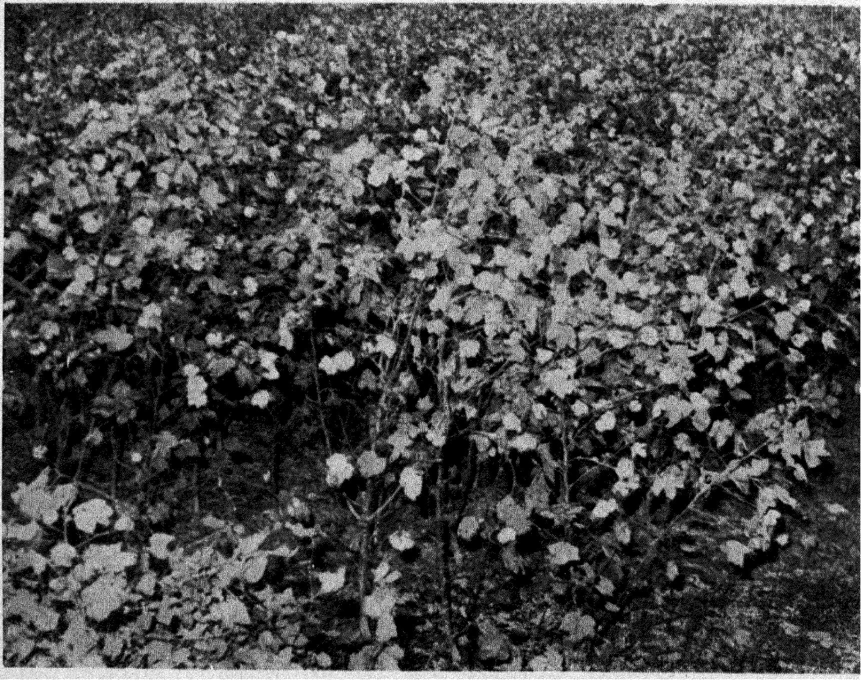


Typical LL.54 Cotton Plant



Characteristics of 35/1 Cotton Plant

a. Crop of 216F Cotton



b. Crop of 320F Cotton

exposed to direct rays of the sun for two-three days during the hot summer months to kill the hibernating larvae in the seed; but as this measure left many loop-holes, the pest survived and the Perso-American cotton could not be grown successfully. Another setback in the case of Perso-American cotton was its greater susceptibility than *desi* cotton to leaf roller (*Sylepta derogata*), whose damage in certain years was so enormous as to denude the plants of almost all its leaves, leaving behind only bare stems.

The growing of American cotton in Uttar Pradesh had almost been given up when the variety P.A. 216F was introduced from the Punjab. Because of its early-maturing habit, it was able to escape to a considerable extent the infestation of pink bollworm and because of its adaptability, it began to flourish from the very start in the land of growers. It is now widely grown in light soils of western districts of Uttar Pradesh. A brief account of the two prevalent varieties, 35/1 and 216F, is given below :

Arboreum Variety 35/1. It is suitable for humid areas of the State, such as the Meerut and Rohilkhand regions of Uttar Pradesh comprising the districts of Meerut, Muzzaffarnagar, Saharanpur, Moradabad and Bijnor. This is a selection from indigenous cotton collected from the Rohilkhand region during the cotton survey in Uttar Pradesh from 1933 to 1937. It was released for distribution in 1950.

The plant of strain 35/1 is four to six feet in height. Its branching is sympodial, with stems of somewhat purplish colour. The leaves are medium in size; cut into narrow lobes; usually five in number and accute in shape. The flowers are white, with a red blotch at the base of the petals. The bolls are tapering in shape with three to four loculii. It is early-maturing in habit and is a high yielder. Its main economic characters are shown in Table 68 (Gupta, 1959) (Plate VII).

TABLE 68. ECONOMIC CHARACTERS OF SELECTION 35/1

Character	Value
Yield of *kapas* per acre (lb.)	800
Mean fibre length (inches)	0·86
Ginning percentage	36
Pressley strength index	8·3
Highest standard warp counts	16's
Resistance to pests and diseases	Resistant to wilt

As the new improved strain 35/1 is superior to the previous improved variety, C.520, in yield as well as in the quality of lint, it soon became very popular. Though a start was made with it in 1950 with a few acres only, it has come to occupy about 40 per cent. of the total cotton acreage of the State as indicated in Table 69.

TABLE 69. SPREAD OF SELECTION 35/1 IN UTTAR PRADESH

Year	Acreage under 35/1	Total cotton acreage in the State	Percentage area under 35/1
1952	5,526	2,07,000	2·6
1953	17,618	1,82,027	9·7
1954	17,848	1,45,760	12·2
1955	45,345	1,36,122	33·3
1956	63,397	1,46,791	43·2
1957	76,060	1,96,200	38·8

The variety 35/1 has become popular with Uttar Pradesh mills because of its superior quality and consequently its production is on the increase.

Punjab-American 216F. This variety was evolved in the Punjab at Hansi. The account of its evolution, morphological and economic characters has already been given. Its performance as observed in Uttar Pradesh is summarised in Table 70.

TABLE 70. PERFORMANCE OF P.A. 216F IN UTTAR PRADESH

Character	Performance value
Yield of *kapas* per acre (lb.)	900
Mean fibre length (inches)	0·92
Ginning percentage	33
Pressley strength index	8·8
Spinning value	32's
Resistance to pests and diseases	Fairley resistant to jassid but attacked by leaf roller (*Sylepta derogata*)

It was introduced in Uttar Pradesh in 1950 and became successful at once because of its early-maturing habit and flexibility in adapting itself to the new agricultural conditions. Since then the area under it is on the increase, as can be seen from Table 71.

TABLE 71. SPREAD OF P.A. 216F IN UTTAR PRADESH

Year	Acreage under 216F	Percentage of the total cotton acreage of the State
1952	18,019	8·7
1953	22,181	12·2
1954	36,362	24·9
1955	40,510	29·8
1956	41,237	28·0
1957	67,824	34·6

This variety now occupies more than one-third of the cotton acreage of the State. The most suitable region for its cultivation is the western part of

Uttar Pradesh comprising the districts of Bulandshahr, Aligarh, Mathura, Agra, Etah and Mainpuri, where the annual rainfall varies from 20 to 30 inches and where the soils are sandy-loam in nature.

IMPROVED VARIETIES OF COTTON IN NORTH-WEST RAJASTHAN

In North-west Rajasthan, Sriganganagar is the only district where irrigation is available and cotton is grown as an important cash crop. The total area under cotton is 1,21,000 acres (1958-59), which is steady from the last several years. The chief varieties of cotton grown are P.A. 320F, infiltrated from the Punjab; Ganganagar 1, an improved *arboreum* variety and Rajasthan Desi. The acreage under them is shown below :

Variety	Area (acres)
P.A. 320F	61,515
Ganganagar 1	54,980
Others	4,505

It will be observed that 96 per cent. of the area is under improved varieties; 50 per cent. under P.A. 320F and 46 per cent. under Ganganagar 1 and only 4 per cent. of the area is under un-improved types. As the Sriganganagar tract is contiguous to the Abohar tract (in the Ferozepur district of the Punjab) and their climate and soil conditions are almost similar, the performance of P.A. 320F with regard to yield and fibre characters is almost of the same order in both tracts.

Ganganagar 1. This is an *arboreum* selection from material originally gathered from Rohilkhand in Uttar Pradesh. It was released in 1942, but as during the Second World War, there was very poor demand for *desi* cotton, it could not make any head-way. However, its cultivation was revived in 1953, when it was grown on 2,000 acres; since then area under it has been on the increase and it covered 45,980 acres in 1958-59. The plant of Ganganagar 1 is erect-growing, with narrow five to seven lobed leaves, white flowers with an eye, and small bolls. The economic characters of Ganganagar 1 and C.520 (an improved variety of Uttar Pradesh) are compared in Table 72 (Simlote, 1959).

TABLE 72. COMPARISON OF ECONOMIC CHARACTERS OF GANGANAGAR 1 AND C.520

Character	Ganganagar 1	C.520
Yield of *kapas* per acre (lb.)	1,155	1,083
Lint per acre (lb.)	465	388
Mean fibre length (inches)	0·70	0·72
Ginning percentage	40·3	35·8
Spinning value	10½'s	9½'s
Fibre weight per inch (× 10^{-6}oz.)	0·239	0·234

The variety Ganganagar 1 is particularly superior in yield and ginning percentage, and consequently its lint yield per acre is more, due to which an additional income of Rs. 20 to Rs. 25 accrues to the grower. The area under it is, therefore, on the increase, particularly, in the marginal lands, where sufficient water supply is not received. On lands, where water duty is adequate, the growing of variety P.A. 320F is preferred.

SEED MULTIPLICATION AND DISTRIBUTION

The breeding of improved strains is only a means to an end and not an end in itself. The effectiveness of improved strains in increasing production and improving the quality of cotton largely depends on the successful operation of multiplication and distribution of their pure seed. In this connection, the fact has to be borne in mind that maintaining purity of seed in cotton is not as easy as in other crop plants. In the first instance, although cotton is a self-fertilised plant, considerable cross pollination takes place in it. Secondly, seed cotton (*kapas*) has to be ginned in the ginning factories for obtaining seed and even if the crop raised in the field is absolutely pure, there is every likelihood of mixture taking place in the ginning factories, either deliberately or inadvertently. It is apparent that due care has to be taken both in the field and in the ginning factories for maintaining the purity of the seed. In Egypt, over 90 per cent. of the cotton acreage is sown with seed distributed by Government agencies and no seed is allowed to be sown, which does not conform to the standard. It is mainly on this account that Egypt is maintaining the high quality of its cotton.

DIFFERENT STAGES OF SEED MULTIPLICATION

In pre-partitioned Punjab, the Department of Agriculture had the advantage of having a large number of big seed farms of its own, where sufficient quantities of pure seed of cotton and other crops could be produced. Apart from these farms, there were a number of big grantee farms, the owners of which were committed to multiply the seeds of improved varieties and hand over the produce to the Department of Agriculture. As a result of the partition, all the big seed farms as well as the grantee farms went to Pakistan. This has created a bottleneck in large-scale multiplication and distribution of pure seed of improved strains. Nevertheless, for cotton, a system of seed multiplication through different stages was worked out soon after partition, which has helped to cover large areas by improved strains. The seed of improved strains is multiplied through four or five different stages, which enable a regular flow of pure seed to be maintained year after year. The salient features of the different stages are given below :

Stage I. It comprises the raising of selfed seed of an improved strain. For this purpose, a large number of representative plants of the strain, generally two to three thousands, are selected in the field, before flowering starts. Later tips of flower buds of each selected plant, which are expected to open in the following morning, are tied with a cotton thread in the afternoon. The thread is tied in such a way that the flower does not open but, at the same time, the thread remains hanging to the boll until maturity. In this way extensive selfing is continued throughout the flowering period. At the time of picking, produce from all such selfed bolls of each selected plant is harvested separately and examined for various fibre and seed characters. Later, the seed cotton from all such selfed bolls, which conform to the norm of the strain, for fibre and seed characters is bulked and ginned for obtaining selfed seed.

Stage II. It consists of raising nucleus seed, for which purpose the selfed seed obtained under Stage I, is sown in an area of one or two acres, depending upon the quantity of the selfed seed available. The seed is sown in a well prepared seed bed by dibbling at appropriate spacing, in order to ensure good germination and obtain a high yield. In the nucleus plot, two to three thousand typical plants are again selected for raising selfed seed for next year. All the off-type plants are removed as soon as they are detected. Later, the produce from the whole plot is picked and bulked for obtaining the nucleus seed. Only the first two pickings are utilized for this purpose.

Stage III. The nucleus seed is sown in an area of 50 to 60 acres at a Government Seed Farm for raising the foundation seed. The fields are examined at regular intervals for the removal of off-type plants. The produce is ginned under the direct supervision of an official of the Department of Agriculture.

Stage IV. The foundation seed is further multiplied either at the Government Seed Farm and, if the area is not sufficient, on the fields of selected growers in a specially demarcated zone. In the Punjab this is known as the 'inner reserve area' and the growers selected for this purpose are generally progressive cultivators, who are known to take active interest in the improvement of agriculture. These cultivators are supplied with the foundation seed on the express undertaking that they will carryout the roguing operations under the supervision of the departmental officials and will also dispose of their produce as directed by the latter. Generally, the produce is sold by auction and the ginning is done under the supervision of the department, which purchases the seed for further multiplication and distribution.

Stage V. If sufficient seed is not forthcoming from the inner reserve area, the seed procured from Stage IV is further multiplied on the fields of cultivators in compact blocks known as 'outer reserve area'. In the Punjab, in order to facilitate and ensure the growing of a single variety in the outer reserve area, the 'Improved Seed and Seedlings Act of 1949' is enforced in the areas selected for this purpose. Under this Act, it is an offence to grow any variety other than the one recommended by the Department of Agriculture. The whole area is subjected to thorough roguing and, later, the produce from that area, which is likely to yield sufficient seed for covering a given acreage, is procured by the Department of Agriculture for obtaining the requisite seed. The sale and ginning of this produce, as in case of Stage IV produce, is done under the supervision of the department.

The above is only a broad outline of the method followed in multiplying seed of improved varieties in this region. But the procedure given above deviates according to the conditions prevailing in different States. The first three stages, i.e., producing of selfed seed and raising of nucleus and foundation seed are executed at the experimental stations concerned. This is necessary from a technical point of view too. A diagram showing the different stages of seed multiplication and their inter-relationship with one another is given below (Fig. 12). The area to be sown under different stages depends on the facilities available and the quantity of seed required to be multiplied.

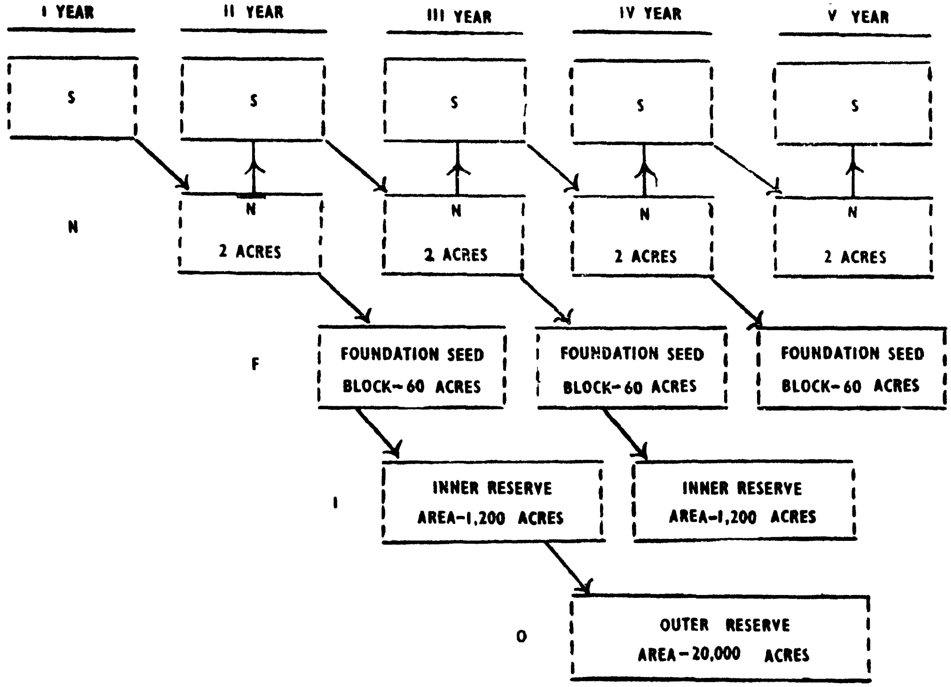


Fig. 12. Diagram Showing Stages of Seed Multiplication

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S = Plot for selfing } at the Breeding Station
N = Nucleus seed
F = Foundation seed block at the Seed Farm of the Agricultural Department
I = Inner reserve area under registered growers
O = Outer reserve area

It may be noted here that one of the most important operations, which requires special attention in the course of multiplying through different stages, is rouging of off-type plants. Such plants may appear in the fields, in spite of all care, either due to an accidental mixture or for some other reason. While the distinction between plants of *desi* and Upland (American) cotton is not difficult even at an early stage, that between the varieties of American cotton is often difficult until the flowering starts. Although the necessity of removing off-type plants is apparent, the cultivators are often reluctant to take voluntary action in this matter and accordingly the roguing operations have to be supervised by the Department of Agriculture over as large an area as possible. This is done jointly by the extension staff and the staff of the seed multiplication and distribution schemes, financed by the Indian Central Cotton Committee. This staff, apart from supervising roguing operations in the inner and outer reserve areas, from where the seed is to be procured for further distribution, impresses upon the cultivators that a negligible reduction in yield due to removal of off-type plants will more than offset the better price that the cultivators will obtain for the pure crop. In the Punjab, the grower in the inner and outer reserve areas, which are subjected to thorough roguing, obtain a premium of Re. 1 to Rs. 2 per maund of *kapas* for their produce over the highest market rate. As a result of this the cultivators have begun to realize the value of raising a pure crop of cotton and it is a pleasing site to see field after field of uniform and pure crop of American cotton in many regions (Plates VIII a and b), particularly in the Ferozepur district. Incidentally, the cost of roguing operations is very nominal. A person, with a little training, can easily rogue five to six acres every day. This would mean a cost of about 30 nP. per acre or less than 6 nP. per maund of seed.

SEED PROCUREMENT AND DISTRIBUTION

The seed is generally procured at a few important centres and is transported by rail or road or other means of transport to the seed depots run by the Agriculture Department or the co-operative society, set up in villages, to which the neighbouring growers have an easy access. The seed from these depots is purchased by the growers according to their requirements on cash payment and a list of the purchasers is maintained at the depot. Because the seed is procured by the Department at a premium, and to it is added the transportation, bagging, handling and commission charges of the sale agent, the rate of Departmental seed usually exceeds the market rate of cotton seed by Re. 1 to Rs. 2 per maund. Even at this difference, the seed generally finds ready sales.

Private shopkeepers in the villages take the general seed from the market. Their seed for sowing as well as for feeding to cattle finds sale, because it is available to the growers more easily, at a cheaper rate, and on credit. The cheapness and sale on credit are the chief attractions for which purity and reliability are sacrificed by some needy growers.

As the American varieties of cotton are not easily ginnable on hand gin (*belna* or *charkha*) and their lint cannot be easily used for domestic purposes, very little of their own seed is used by the cultivators for sowing purposes, nor any prior arrangement for seed is made by him, but on the other hand, usual practice is to purchase the seed just a day or so earlier than the date of sowing. Because he is in a hurry, he goes in for the seed that is near at hand. As the seed depots of the Department are not in each and every village, the seed available from the local shopkeepers is taken.

SEED DISTRIBUTION SCHEMES IN NORTHERN ZONE

The Indian Central Cotton Committee has been sanctioning funds from time to time for the functioning of these schemes, so that the benefit of research and evolution of new improved varieties may reach the growers. A very brief account of the schemes that have been functioning in the past and are operating at present will not be out of place.

Scheme for Multiplication and Distribution of L.S.S. Cotton in the Punjab. The scheme functioned for a period of five years from 1-3-1948 to 28-2-1953, at a total cost of Rs. 94,805 to the Indian Central Cotton Committee. The object of the scheme was to multiply and distribute pure seed of Punjab-American cotton L.S.S. in the Ferozepur district, whereas previously *desi* and mixture of 4F and L.S.S. were being grown there. Immediately after the commencement of the scheme, the variety L.S.S. was purified by making a large number of single plant selections, and its yielding capacity, grade and quality were improved, as shown below (Table 73).

TABLE 73. PURE L.S.S. *verses* COMMERCIAL L.S.S.

Year	Yield of *kapas* (maunds per acre)		Average market price of *kapas* per maund (Rs.)	
	Pure L.S.S.	Commercial L.S.S.	Pure L.S.S.	Commercial L.S.S.
1950-51	9·9	8·5	43·47	41·86
1951-52	10·2	8·6	42·12	41·62
1952-53	11·5	9·9	34·62	32·62

On account of the better yielding capacity of pure L.S.S. and the premium it commanded in the market, its seed was greatly in demand. During the life-span of five years of the scheme, a total of 32,294 maunds of seed was distributed departmentally and 25,006 maunds by other agencies, which resulted in an additional income of Rs. 1.85 crores to the growers of the district, as shown in Table 74.

TABLE 74. STATEMENT SHOWING QUANTITY OF L.S.S. SEED DISTRIBUTED IN FEROZEPUR DISTRICT AND ADDITIONAL GAIN TO GROWERS

Year	Quantity of seed distributed (mds.)		Estimated additional income (Rs.)	
	Departmental seed	Other agencies	Per acre	Total
1949-50	5,259	3,247	—	—
1950-51	8,522	6,328	74·55	49,85,099
1951-52	8,578	7,666	71·69	60,96,277
1952-53	9,935	7,765	75·19	74,69,878
Total	32,294	25,006	—	1,85,51,254

The acreage and production of L.S.S. increased manifold in Ferozepur district due to the working of the scheme and the enthusiasm of the growers (Table 75).

TABLE 75. INCREASE IN AREA AND PRODUCTION IN FEROZEPUR DISTRICT

Particulars	1948	1949	1950	1951	1952
Area (acres)	42,902	85,066	1,48,500	1,62,400	1,77,000
Production (bales)	22,628	53,422	72,502	96,760	1,24,012
Percentage increase in area over 1948	—	98	246	278	312
Percentage increase in production over 1948	—	136	220	328	448

Scheme for Multiplication and Distribution of 216F Cotton in the Punjab. The scheme was started in 1950 for a period of five years at a cost of Rs. 59,135 to the Indian Central Cotton Committee to multiply and distribute pure seed of 216F in the four South-eastern districts of the Punjab, viz., Hissar, Rohtak, Karnal and Gurgaon. This tract had been growing *desi* cotton exclusively but as a suitable variety of American cotton, with a very superior lint, had been evolved under the scheme for improvement of cotton at Hansi, it was intended to replace *desi* cotton with the new American variety, namely, 216F.

During the five years of the working of the scheme a total of 52,623 maunds of 216F seed was distributed by the Departmental agencies and 22,797 maunds by other agencies, and in the final year, 69 per cent. of the total cotton area of the tract was covered by 216F. The year-wise progress is given in Table 76.

Comparative trials had shown that 216F had a better yielding capacity than *desi* cotton. The consequence was that the yield per unit area in the

TABLE 76. QUANTITY OF SEED DISTRIBUTED AND AREA COVERED BY 216F IN SOUTH-EASTERN TRACT OF THE PUNJAB (1950-51 TO 1954-55)

Year	Quantity of seed distributed (maunds)			Area covered (acres)			Percentage of total area
	Depart-mental seed	Other agencies	Total	Depart-mental seed	Other agencies	Total	
1950-51	1,300	—	1,300	6,600	—	6,600	6·5
1951-52	6,487	1,880	8,300	27,500	7,500	35,000	29·6
1952-53	11,564	2,087	13,651	46,000	8,348	54,348	50·8
1953-54	15,079	3,330	18,409	60,300	13,316	73,616	57·8
1954-55	18,193	15,500	33,693	72,000	62,000	1,34,000	69·0

whole tract advanced with the graded increase of the American variety. This aspect is depicted in Table 77.

TABLE 77. AVERAGE YIELD OF COTTON PER ACRE IN SOUTH-EASTERN TRACT OF THE PUNJAB

Year	Area (thousand acres)	Production (thousand bales)	Yield of lint per acre (lb.)
1950-51	111	43	152
1951-52	120	53	173
1952-53	108	49	178
1953-54	128	73	223
1954-55	193	117	238

The 216F has always been commanding a handsome premium on *desi* cotton in the market on account of its superior quality and, therefore, has been giving a higher cash return per acre. During the life span of the scheme, an additional income of Rs. 3.07 crores accrued to the growers of 216F as indicated below in Table 78 (Negi and Avtar Singh, 1956a).

TABLE 78. ESTIMATED ADDITIONAL INCOME TO COTTON GROWERS OF HARIANA TRACT AS A RESULT OF DISTRIBUTION OF PURE SEED OF 216F

Year	Yield (maunds per acre)		Price of *kapas* per maund (Rs.)		Additional income per acre (Rs.)	Total additional income (lakh rupees)
	Desi	216F	Desi	216F		
1950-51	8·0	9·3	32·25	51·75	223·00	14·72
1951-52	8·0	9·3	25·75	42·00	184·00	64·40
1952-53	7·0	7·9	20·37	32·25	112·00	60·87
1953-54	7·0	7·9	26·06	36·19	103·00	75·82
1954-55	8·0	9·0	20·56	25·88	68·50	91·79

Scheme for Multiplication and Distribution of H.14 Cotton in South-eastern Districts of the Punjab. For the South-eastern tracts of the Punjab, another improved variety of the American cotton, namely, H.14 was evolved and brought on the approved list of seeds in 1954. The new variety was evolved by selection from previous improved variety P.A. 216F, and was an improvement on the latter in many respects; it yielded on the average 116 lb. more *kapas* per acre; recorded 1.4 per cent. higher ginning outturn; had the higher spinning value by six counts; and gave Rs. 88 greater cash return per acre. As the new variety was highly desirable, the Indian Central Cotton Committee sanctioned a scheme for multiplication and distribution of its seed from 16-8-1956 for a period of 2½ years at a total cost of Rs. 37,700, with the objective of replacing P.A. 216F and other types being grown in the tract.

During the two years of the working of the scheme and prior to it, since the release of the variety, a total of 42,632 maunds of H.14 seed was distributed by the Departmental agencies and 14,000 maunds by other agencies; its other details as well as the area covered by the variety are contained in Table 79.

TABLE 79. QUANTITY OF SEED DISTRIBUTED AND AREA COVERED BY H.14 IN SOUTH-EASTERN TRACT OF THE PUNJAB (1954-58)

Year	Quantity of seed distributed	Estimated area covered (acres)			Total cotton acreage in the tract	Percentage area under H.14	Estimated additional income to the grower over 216F (Rs.)	
		Departmental seed	Non-Departmental seed	Total			Per acre	Total
1954-55	200	800	—	800	1,93,000	0·4	—	—
1955-56	2,000	9,976	—	9,976	1,87,000	5·3	—	—
1956-57	9,032	40,000	12,000	52,000	2,67,000	19·5	63·40	32,96,800
1957-58	31,400	1,25,600	39,400	1,65,000	3,93,000	41·9	37·24	61,38,000

It will be observed that in the short period of four years, since its release, the variety P.A. H.14 covered 42 per cent. of the cotton area of the tract and gave over 94 lakhs of rupees as additional income to the growers. It is planned to increase the life-span of the scheme in order to saturate the entire tract with the new variety.

Scheme for Multiplication and Distribution of 320F Cotton in the Punjab. The 320F is an early-maturing variety of American cotton. It was originally evolved for the central and sub-montane districts of the Punjab to replace *desi* cotton, but it has also been found admirably suitable for the Ferozepur district, where the growing of L.S.S. was common. A scheme for the multiplication of its seed was started jointly by the Indian Central Cotton Committee and the Punjab Government, in 1953, and is still in progress. This variety has proved a tremendous success; during the short period of three years, it has covered 64.8 per cent. of the cotton acreage of the zone, for which it was released, as shown in Table 80 (Negi and Sehgal, 1957).

TABLE 80. PROGRESS IN SPREAD OF AREA UNDER 320F IN FEROZEPUR, AMRITSAR, JULLUNDUR AND LUDHIANA DISTRICTS OF THE PUNJAB

Year	Quantity of departmental seed distributed (maunds)	Area covered (acres)	Total area under cotton (acres)	Percentage area under 320F
1952-53	600	34,120	3,50,570	9·7
1953-54	22,567	1,64,886	4,12,183	40·0
1954-55	34,121	3,14,454	5,26,414	59·7
1955-56	40,205	3,48,655	5,38,041	64·8

On the basis of regular trials conducted at different places, 320F has been found to be superior to L.S.S. as well as *desi* cotton in yielding capacity by 1.5 to 2.9 maunds per acre. Its market rate, as indicated in Table 61 is higher. It will, therefore, materially add to the prosperity of the growers.

Scheme for Multiplication and Distribution of Cotton Seed in Pepsu. The scheme came into operation in 1952 and is to run for a period of five years. The cost is being borne jointly by the Indian Central Cotton Committee and the Pepsu Government. The object of the scheme is to replace the *desi* and L.S.S. cottons being grown in the Bhatinda tract of Pepsu by 320F, and *desi* in the Dhuri tract by 216F. During the three years' working of the scheme, 34,000 maunds of pure seed of 320F and 216F has been distributed, resulting in a total additional income of about rupees three crores to the cotton growers as shown in Table 81.

Scheme for Seed Distribution and Extension of 35/1 Cotton in Uttar Pradesh. This scheme came into operation in 1952, and is still continuing. The object is to replace C.520, the old *desi* improved variety, by 35/1, a new *desi* variety, which is superior in technological properties to the former. The Uttar Pradesh textile mills have liked 35/1, as it has been found to spin 12's to 14's counts under mill conditions. The scheme covers the five districts of Saharanpur, Muzzaffarnagar, Meerut, Bijnor and Muradabad. The summary of progress made under the scheme, since its inception, is given in Table 82.

TABLE 81. PROGRESS IN PURE SEED DISTRIBUTION AND ESTIMATED ADDITIONAL INCOME TO GROWERS IN PEPSU

Year	Quantity of departmental seed distributed (mds.)	Estimated area covered (acres)			Estimated additional income (Rs.)	
		Departmental seed	Non-departmental seed	Total	Per acre	Total
1952-53	4,000	32,000	48,000	80,000	80	64,00,000
1953-54	12,000	96,000	64,000	1,60,000	85	1,36,00,000
1954-55	18,000	1,44,000	72,000	2,16,000	40	86,40,000

TABLE 82. QUANTITY OF 35/1 SEED DISTRIBUTED, AREA COVERED AND ADDITIONAL INCOME TO GROWERS

Year	Quantity of seed distributed (mds.)	Estimated area covered (acres)			Estimated additional income (Rs.)	
		Departmental seed	Non-departmental seed	Total	Per acre	Total
1952-53	540	3,126	2,400	5,526	20·00	1,10,520
1953-54	464	2,824	14,794	17,618	20·00	3,52,360
1954-55	1,046	5,327	12,521	17,848	14·50	2,58,796

It will be observed that the seed ditribution schemes have been the means of changing the face of the country. Whereas, previously, mostly *desi* cotton was grown in this region, now over 70 per cent. of the cotton area has been covered by long-stapled, superior American varieties, thereby ameliorating considerably the lot of the growers.

There is further need for such schemes for distributing the seed of American cotton in Uttar Pradesh in the districts adjoining the Punjab and in the Sriganganagar area of Rajasthan.

COTTON LEGISLATION

The role of legislative measures in agriculture has been well recognized. In a crop like cotton, where the quality counts most, such legislation is enforced in all the advanced cotton-growing countries of the world. The Government of India on the recommendation of the Indian Central Cotton Committee have brought forth several Acts to regulate the growing of varieties in one-variety communities, effectively, to control pests and diseases and to make mixing or watering of cotton a penal offence. Most of these Acts have been adopted in the Northern *hirsutum-arboreum* Region. In addition the Government of Punjab have also enforced certain legislative measures, which are briefly described below:

The East Punjab Improved Seed and Seedlings Act, 1949. This Act provides for the use of pure and certified seeds and seedlings of the improved varieties of the crops recommended by the Department of Agriculture in the Punjab. According to it, an area to which this Act is to be made applicable is notified and the improved variety or varieties of crops to be grown in the area are also declared. Pure and certified seed of these varieties is made available by the Agricultural Department through authorised agents. To refuse to sell improved seed and to stock seed other than improved seed by the authorised agent are both punishable under the law. The growing of any variety other than that approved by the State Department of Agriculture is also an offence. The movement of seed from one area to another is also prohibited. Under this Act, the improved varieties of cotton and the areas specified for them in the Punjab are as under:

Variety	Area specified
L.S.S. —	Fazilka and Muktsar *tehsils* of Ferozepur district.
320F —	Districts of Amritsar, Jullundur, Ludhiana, Ferozepur (excepting eastern canal zone), Batala *tehsil* of Gurdaspur district, Dabwali sub-*tehsil* of Hissar district, Faridkot *tehsil* in Bhatinda district.
216F —	District of Hissar (excepting Dabwali sub-*tehsil*), Rohtak, Karnal, Mansa *tehsil* in district Bhatinda and villages of Maur Police Station, Bhatinda *tehsil*.

This Act has been very helpful in disseminating and popularizing new varieties of cotton along with those of other crops.

The Punjab Cotton Seed Control Order (Issued under the Essential Commodities Act). This order is promulgated in the cotton-growing areas of the State every year. The object is to disseminate seed of a particular variety of cotton in a specified area.

According to the provisions of this order all the cotton seed dealers are required to take out a licence for conducting business in cotton seed; they are prohibited from mixing seeds of American varieties of cotton amongst themselves or with *desi* varieties of cotton, and they can sell only the seed of a specified variety of American cotton (viz., L.S.S., 216F, 320F or any other American variety), that have been certified fit for sowing purposes. Any contravention of these provisions is punishable with suspension or cancellation of the licence.

The East Punjab Agricultural Pests, Diseases and Noxious Weeds Act, 1949. This Act is meant to provide for the prevention of the introduction, spread or reappearance of pests, plant diseases and noxious weeds injurious to crops, plants or trees in the Punjab State. According to the provisions of this Act, the area where it is intended to control the pest, disease or weed is specified; the pest, etc., to be controlled is declared and the remedial measures to be adopted and the time limit within which they should be carried out are prescribed by the State Government. It is made obligatory on the cultivator to carry-out the eradiction measures on the affected area or crop, failing which their control measures are liable to be adopted at his cost, which is recoverable from him as an arrears of land revenue.

The Punjab Agricultural Produce Markets Act, 1939. The Act provides for better regulation of the purchase and sale of the agricultural produce and establishment of regulated markets in the Punjab.

Practically all the important markets in the Punjab have been regulated under this Act and it has been made applicable to cotton and several other agricultural commodities. Under the Act, the cultivator has been saved from the payment of excessive charges, which have now been fixed for different intermediaries and others, who handle the produce, such as the commission agent, weighman, *paledar*, broker, etc.; the produce is sold by auction and there is no underhand method of settling the price; and the standard weights and measures are in vogue.

The Punjab Cotton Ginning and Pressing Factories Act, 1953. The Act repeals the former Cotton Ginning and Pressing Factories Act of 1925. The new Act provides for better regulation of cotton ginning and pressing factories in the Punjab. The following are its main provisions.

1. The owner of a ginning factory is required to maintain ginning and pressing registers in prescribed forms.
2. For maintaining the purity of cotton in specified areas admixture or cotton in ginned state in a factory has been made an offence.
3. Watering of cotton and presence in it of seed in excess of the prescribed proportion (0.5 per cent.) or foreign substance or cotton waste is a contravention to the provisions of the Act and is punishable.
4. Marking of the bales with serial number and press mark; marking of the bales which contain cotton from the previous and current season in mixture in such a manner that they can be distinguished from the former has been made obligatory on the factory-owner.
5. The cotton ginning factories are required to submit, in a prescribed form, a monthly return showing the quantity of *kapas* ginned during the preceding month and also the total quantity ginned from the commencement of the season to the end of the month to which the return relates. Similar, but weekly returns, have to be submitted in respect of the bales pressed. The average net weight of the bale during the week is also to be indicated.
6. Use of scale and weights prescribed by the State Government under the Punjab Weights and Measures Act, 1941, has been made compulsory in a ginning factory.

7. The State Government has taken upon itself to fix charges for ginning or pressing or both for whole or part of the State.
8. In the event of a factory being leased or mortgaged or on the transfer of ownership, the vendor is required to hand over the registers being maintained under the Act to the transferee and on the termination of the lease, etc., the lessee should return them to the owner.
9. Construction of the factory should be according to the approved plan and any alternation or addition made should conform to the approved plan.
10. If a factory is closed in a pool, with a view to depress prices, such a closure is an offence under the Act.

The East Punjab Cotton Statistics Act, 1948. This Act facilitates the collection of statistics of stock of Indian raw cotton in the State. Under this Act, every trader and owner of a cotton ginning and pressing factory is required to submit monthly figures of stock of cotton, variety-wise, held by him, to the Director of Agriculture.

The Cotton Transport Act of 1923. It is a Central Act but has not yet been enforced in the Punjab or Uttar Pradesh.

Uttar Pradesh Cotton Pest Control Act, 1936. It provides for a proper treatment of cotton seed against pink bollworm.

ECONOMICS OF COTTON PRODUCTION

Conditions obtaining in northern India, particularly those in some parts of the Punjab and Rajasthan, are favourable for the production of cotton. The climate is fairly suitable. The summers are warm and long. The sowing time of American cotton has been so adjusted by cultivators that the monsoons occur at a time when the plant is young and are good for its vegetative growth. The rainfall is scanty during picking time. This is desirable, so that *kapas* in open bolls is not spoiled. The deep alluvial soils of the plains are productive and suit the cotton crop very well. Irrigation water is available mostly from the canals and other sources, which can be applied, wherever necessary. The cultivators are hardy and painstaking. Artificial fetilizers,l ike ammonium sulphate, to which cotton gives a good and economic response, is readily available in the market and is being produced in India itself. Other products to increase the production of this fertilizer are underway. Ginning centres have cropped up in the cotton producing areas, where the produce is readily saleable at competitive rates. For these reasons, the cotton is a favourite crop of the growers in most areas of northern India.

Cotton and Other Summer Crops. Cotton is sown during the months of April and May. It occupies the land for about six to seven months, i.e., till November. In some areas, depending upon the type of varieties sown and the time of sowing, cotton is not over till the end of December. The other summer crops, that usually remain in the field for a part or whole of this period, are *bajra*, maize, paddy, groundnut and sugarcane. Paddy and groundnut are special crops and do not normally come in competition with cotton, as the former is grown only in stiff heavy soils, where an assured and plentiful supply of water is available, and the latter on very light sandy soils, where growing of other crops is not remunerative. *Jowar* and *bajra* are grown for grain as well as for fodder purposes, mostly under unirrigated conditions on light soils. Maize and sugarcane do compete with cotton. Sugarcane occupies the land for almost the whole of the year. Though its gross income is higher than that of cotton, yet due to its long growing period, high cost of production, labour requirements and the laborious process involved in its conversion into a saleable product, viz., *gur*, except in sugar factory zones, where the disposal of cane as such is possible; its area cannot be beyond a certain limit. Maize, no doubt has a short life cycle, viz., three and a half months, but it can be grown successfully under mild climatic conditions, and where the supply of water and manure is plentiful, while cotton does well in dry hotter parts of northern India, where, of course, adequate supplies of water are available.

Cost of Production of Cotton. Reliable data on the cost of production of cotton in the country are rather meagre. In the Punjab, however, efforts have been made from time to time to determine the income and expenditure of various crops. The firts information on the subject was published in 1916 by W. S. Hamilton in his Pamphlet "Expenses and Profits of Cultivation in the Punjab," and again by W. Roberts and Faulkner in their Book "A Text-book of Punjab Agriculture" which was, later on, revised by Messrs. Roberts and Kartar Singh. But these figures were the result of personal inquiries made from a few cultivators and a number of years' experience of farming, rather than of systematic and carefully kept accounts. First authentic information on the cost of production of field crops was collected from seven tenant holdings on a Government Estate, near Lyallpur. This inquiry was conducted for five years, from 1927-1932, and the results were published by the Board of Economic Inquiry, Punjab, 1934, under the title "Studies in the Cost of Production of Crops in the Punjab." The scope of this inquiry was subsequently enlarged to 12 one-plough holdings and, in 1944, the Board of Economic Inquiry published the results of studies made for the five years, ending 1939-40. The sample of these studies was very small. Moreover, they were confined only to one Government-owned Seed Farm. The first serious effort was made by the Imperial Council of Agricultural Research (now known as the Indian Council of Agricultural Research), to inquire into the cost of production of crops in the sugarcane and cotton-growing tracts of India. This inquiry was conducted for three years, (1933-35) and results published in 1938. The scheme covered 23 districts and 144 villages, in seven Provinces, viz., Madras, Bombay, Bengal, Uttar Pradesh, Punjab, Central Provinces, Bihar and Orrissa and the three States of Hyderabad, Mysore and Baroda. A lot of useful cost-data were compiled but in the final reports, the figures were given in terms of money, which cannot be made use of under the present-day conditions of farming. A few years ago, a study of Farm Management was started under the National Sample Survey of the Ministry of Finance, Government of India, but the results of this inquiry are not available. However, on the basis of the quantitative data in respect of bullock and manual labour, available from the Board of Economic Inquiry, Punjab, Publication No. 83, entitled "Cost of Crops on a Canal-irrigated Estate in the Punjab, 1935-36 to 1939-40," the cost of production of American cotton has been worked out as follows :

	Rs. nP.
1. Human labour :	
(a) 13.3 man days at Rs. 2 per day	26.60
(b) Picking charges (female labour) 19 days at Rs. 1.25 per day	23.75
2. Bullocks labour 4.9 days at Rs. 5 per day	24.50
3. Eight seers seed at Rs. 12.50 per maund	2.50
4. Manures :	
(a) 10 cartloads of farm yard manure at Rs. 2 per cart (residual effect 50 per cent.)	10.00
(b) 1¼ maunds of ammonium sulphate	15.60
5. Water rate	6.75
6. Land revenue	7.00
7. Rent of land	60.00
8. Depreciation, interest and miscellaneous charges	10.00
Total	186.70

The rent of land alone is the single major item of the cost. Next to this is the human and manual labour in that order. The above-mentioned items account for nearly three-fourths of the cost.

Before the cotton can be disposed off, it is to be transported to the nearest market. The expenses incurred in connection with marketing are the following:

	Rs. nP.
1. Transport of 10 maunds of *kapas* to market at 37 nP. per maund	3.70
2. Marketing expenses at Rs. 1.56 per Rs. 100	4.68
Total	8.38

VALUE OF THE PRODUCE

10 maunds of *kapas* at Rs. 30 per maund	300.00
Total cost of cultivation and marketing expenses	195.08
Net profit per acre	104.92

PER MAUND ASPECT WILL BE AS UNDER	Rs. nP.
Gross value per maund of *kapas*	30.00
Cost of cultivation per maund	19.50
Net profit per maund of *kapas*	10.50

The net profit is much less if *desi* cotton is grown because its yield and market value is lower as compared to American varieties. The cost per maund also increases, if the outturn per acre decreases. The normal average yield in the Punjab is about seven maunds per acre, but on good pieces of land with adequate manuring and irrigation, the yield can be easily doubled.

UTILIZATION OF COTTON SEED AND ITS PRODUCTS

Fibres are the more valuable part of cotton. The seeds have comparatively much less commercial value. The quantity of seed is usually two-thirds of the total quantity of *kapas*. Consequently, the production of cotton seed is roughly double the production of lint. On this basis, India produced 1,733 thousand tons of cotton seed in 1956-57, and the Northern Region 316 thousand tons (Subba Rao, 1959). The production of cotton seed will further increase as the area under cotton is bound to increase, with the augmentation of water supply from the Bhakra Canals and other irrigation projects.

It has been reported that in other countries, cotton seed and its products are being put to a variety of uses. In the United States no less than 1,900 types of articles are manufactured from cotton seed and its products. In India, it has mostly been looked upon as a valuable cattle feed, though in slump years of 1930-32, on account of its cheapness, it was used for fuel in factories in stray cases. Recently, some developments have taken place, by virtue of which cotton seed is looked upon as a profitable source of oil and cheap source of stuffing material, because of the linters yielded by the fuzzy-seeded types.

Categories of Cotton Seed. Athawale (1944) classified different varieties of cotton seed according to the percentage of their oil contents, but from outward appearance, it can be divided into the following three main categories :

1. *Desi* cotton seed. They have very short fuzz. Some *herbaceum* cottons have more pronounced fuzz.
2. Partly naked seed of American varieties like 4F, L.S.S. and 320F.
3. Full fuzzy American seed like 216F, H.14 and Perso-American.

Completely naked seeded types are not grown in the Northern Region.

Desi and semi-naked cotton seeds of the American varieties are seldom used for any other purpose, except for feeding cattle and sowing. In this respect, the Northern Region is deficient in cotton seed and large quantities of cotton seed, particularly of the *desi* variety are imported from other parts of India mainly for feeding the animals. They are not used for extraction of oil on account of their prohibitive cost. On the other hand, there is a false prejudice amongst the people against the fuzzy cotton seed with the result that it is rarely used as animal feed. It is cheaper than the other types of cotton seed and, therefore, most of it goes to crushing mills.

Products of Cotton Seed. The cotton seed is composed of the following physical parts :

1. Linters, the short fibres or fuzz, which remain attached to the seed coat and are not removed during the process of ginning.
2. Hull or the seed coat, which is a dark coloured shell.
3. Kernel, which is the inner part of the seed.

The composition of whole Indian cotton seed is as under (Fig. 13):

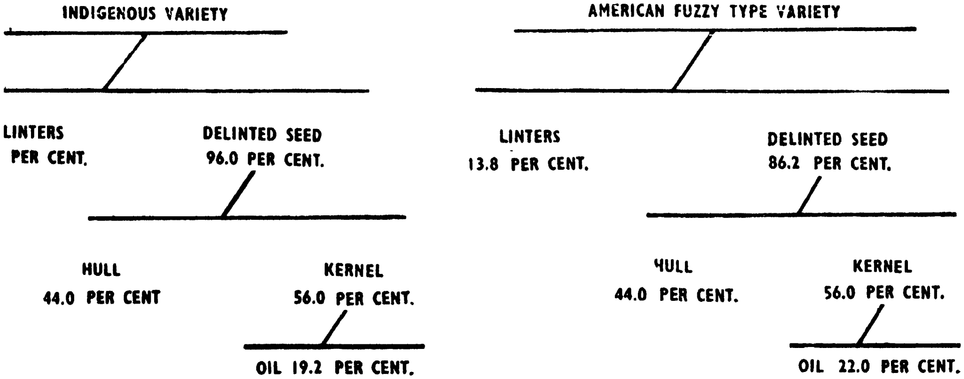

Fig. 13. Composition of Whole Indian Cotton Seed

When the cotton seed is processed, it yields the following products (Table 83).

TABLE 83. PRODUCTS OF COTTON SEED

Product	U.S.A. (per cent.)	Punjab (per cent.)
Crude oil	14·1	14·0
Cake or meal	35·6	37·0
Hulls	47·2	40·0
Linters	1·1	2·0
Waste	2·0	7·0

Processing of Cotton Seed. Two distinct operations are performed in the processing of cotton seed. The first is the removal of linters with the help of delinting machines and the other crushing for extraction of oil.

Delinting of Cotton Seed : In the United States the cotton seed, before processing, is cleaned of impurities, such as leaves, twings, grit, etc., but in northern India, cleaning is not given much importance. The roller-ginned seed is seldom properly processed. Usually, it is passed through expellers for extraction of oil, but the saw-ginned seed is often delinted, as proportion of linters in this case is comparatively higher. Saw-ginned seed is clean and devoid of leaves, twings and other impurities, and, therefore, its pre-cleaning is not necessary. For delinting, the cotton seed is passed through a delinting machine, which works on the same principle as the saw-gin except that the saws have finer and closer-set teeth. In the United States the linters are graded into different lengths and the different grades are put to different uses, but in northern India, gradation of linters is not done and all the linters are collected together. After delinting, the seed is saleable in the market at a premium of about Rs. 1.50 per maund over undelinted seed, as all such seed is preferred for feeding purposes and is considered by animal-owners as being equivalent to the naked or semi-naked cotton seed. A delinting machine is usually capable of processing about 100 maunds of cotton seed during a day. The cost of delinting works out to Re. 1 per maund and the yield of linters is about two maunds. From the commercial point of view, the process of delinting, and disposing delinted seed and linters is profitable.

Crushing for Extraction of Oil : In the United States of America the delinting operation is followed by hulling and separating. In this process, the kernels and hulls are separated and the former are utilized for the extraction of oil with the use of expellers, hydraulic presses or solvent extraction method. In northern India, the whole seed without delinting and, in rare cases, delinted seed is used for oil extraction. For this purpose, only the expellers are used. The hydraulic presses and the solvent extraction method is commercially unknown even though the expeller requires considerably more power. The popularity of expellers for crushing cotton seed is due to the following advantages :

1. Oil extraction is higher.
2. Less Labour is required.
3. More of gossypol goes in oil, which improves its stability and there are low refining losses.
4. Cake is left with smaller quantity of gossypol and is non-toxic as cattle feed.

The 4F and L.S.S. cotton seeds (naked and semi-naked), though available in northern India are not used for extraction of oil, as their cost is prohibitive, because of their keener demand for feeding purposes. However, the extraction of oil in their case is higher, i.e., about 16 per cent. as compared to 13 per cent. from the fuzzy seed. The higher extraction does not compensate the higher cost. Another drawback in the case of naked and semi-naked seeds is the dark and dull colour of the cotton seed cake, which in case of fuzzy is deep yellow and attractive and is readily purchased for feeding to cattle. It is mainly for the cheapness and attractive colour of its cake that the fuzzy seed chiefly goes to the mill for extraction of oil.

The economics of crushing 216F cotton seed for extraction of oil are given below (Gursham Singh, Avtar Singh and Aujla, 1958):

Cost	Rs. nP.
1. Cost of one maund of cotton seed	12.00
2. Crushing expense, depreciation of machinery, labour, bags, containers, supervision and other miscellaneous expenses	1.25
Total	13.25

Income	Rs. nP.
1. 5-3/8 seers oil at Rs. 55 per maund	7.37
2. 33 seers cake at Rs. 8.50 per *maund*—1-5/8 seers loss	7.00
Total	14.37

The net gain per maund of cotton seed is Rs. 1.12 after extraction of oil.

Uses of Linters. The estimated annual production of linters in the Punjab during the pre-war period was about 15,000 bales. The poineers in installing delinting machines in the pre-partitioned Punjab were Messrs B.C.G.A. (Punjab) Limited, Khanewal; Birla Cotton Factory, Okara, and Messrs Prem Singh Deviditta Mal, Burewala, who considered delinting machines as a necessary adjunct to their ginning plants for compensating part of the lint loss in saw-ginning process, from the value of linters and sale of seed at a premium price. A few saw-gins are coming in vogue in the East Punjab and, particularly in the South-eastern zone, where the fuzzy seeded varieties are under cultivation at present. About 40 to 80 lb. of linters from a ton of seed is usually extracted, though a yield of 200 lb. of ungraded linters is possible. These are readily saleable and are put to a variety of uses, such as stuffing of quilts and pillows, padding, preparation of absorbant surgical cotton, mixing with wool, manufacture of ropes and twines, raw material for paper, plastics and artificial fibres like rayon, etc; in preparation of explosives and other industrial products.

Cotton Seed as Cattle Feed. The prejudice against fuzzy cotton seed for feeding purposes is without foundation. Lander and Dharmani (1929, 1935, 1937) did extensive digestibility trials to find the feeding values of different feeds. Their findings regarding cotton seed and cake are summarized in Table 84.

It is common to feed partially naked American cotton seed (i.e., 4F, L.S.S. and 320F) and *desi* cotton seed to cattle but there is a prejudice against fuzzy cotton seed even though it is superior to *desi*, particularly in digestible proteins, and should be given preference for feeding to cattle. But the fact remains that fuzzy cotton seeds are still unpopular and are rarely used for feeding. The cattle-owners believe that on account of its high fibre contents, the cattle do not relish it and when fed in large quantity, they cause digestive

TABLE 84. FEEDING VALUE OF 100 LB. OF SEED

Variety of seed	Per 100 lb. of seed		Albiminoid
	Starch equivalent	Digestible proteins	
Fuzzy American cotton seed (289F/43)	85·95	14·00	6·2
Fuzzy American cotton seed (289F)	68·25	11·50	5·6
Partially naked American cotton seed (4F)	62·85	10·67	5·5
Desi cotton seed	69·57	8·00	8·6
Undecorticated cotton seed cake	60·56	17·97	3·1
Decorticated cotton seed cake	59·36	29·10	1·1
Sarson cake	69·35	28·00	1·7
Toria cake	69·25	27·00	1·8

troubles and the cattle go off feeds. A few people, who feed fuzzy cotton seed to their cattle, take the precaution of cooking and crushing it before putting it before the animals. The advisability of this practice is yet to be investigated.

An important finding of the work of Lander and Dharmani (1937) was that "a fat content of eight per cent. seems to be most fit and the cotton seed cake appears to be most desirable feed", because the fat percentage in the Punjab cotton seed cake is the optimum from that angle, viz., 8.47 per cent. This indicates the desirability of crushing cotton seed for extraction of oil and using the undecorticated seed for feeding to cattle.

The ginned cotton seed contains phenolic substance of toxic physiologic effects named as gossypol. It is a pigment of light yellow colour occurring in concentration of 0.4-2 per cent. on the weight of the kernel. Some of it passes on with the oil, when it is extracted, and the remnant in the cotton seed cake is not toxic. This is another reason for preferring cotton seed cake to cotton seed as feed for cattle.

Cattle fed exclusively on cotton seed and green fodder produced *ghee* high in refractive index and iodine value with lower Reichert-Meisel and Plolenske values and greater stability to oxidative spoilage as compared to *ghee* obtained from cattle, fed on straight green fodder ration. The absorption and secretion of carotine and vitamin 'A' in butter fat was poor, when the ration was predominantly cotton seed (Patel and Ray, 1949).

Hulls as Cattle Feed. Hulls are not separated in northern India, as cotton seed is crushed as whole. However, if separated, they can form a valuable cattle feed.

Hussain *et al.* (1951) found that hulls, i.e., the cotton coat or the dark colour shells of Indian cotton seeds, contained 40 to 60 per cent. total digestible nutrients and 0.38 per cent. digestible proteins. Cattle could eat 20 lb. hulls per day and the hulls were preferred to wheat straw. They recommended supplementing the hulls with silage legume hay or with good quality green fodder, or with calcium and phosphorus in mineral form, since the cotton seed hulls are low in calcium and phosphorus.

Cotton Seed Meal as Human Food. The chemical analysis of cotton seed is shown in Table 85.

TABLE 85. CHEMICAL ANALYSIS OF COTTON SEED

Type of seed	Moisture	Dry matter	Ash (per cent.)	Fat (per cent.)	Fibre (per cent.)	Protein (per cent.)	Nitrogen free extract (per cent.)
American cotton	9·92	99·08	4·74	19·45	22·57	19·38	23·94
Punjab 289F	6·33	93·67	4·95	18·77	26·20	18·13	25·62
Punjab 4F	6·71	93·29	4·63	20·73	20·96	17·50	29·47
Punjab Desi	6·78	93·22	4·73	17·64	21·67	14·38	34·80
American cotton seed cake	8·52	92·48	7·02	13·45	4·44	43·26	23·21
Undecorticated Punjab seed cake	7·48	92·52	6·08	8·47	28·31	23·13	34·60

Cotton seed is a valuable source of fat and protein. The cotton seed flour obtained from a specially processed cake, is rich in certain vitamins and essential amino acids and is practically free from starch. In the United States, for a ton of cotton seed about 950 lb. of meal containing 23 per cent. of protein is available, which yields about 300 lb. of edible cotton seed flour. The flour has a light colour and a rather pleasant and characteristic nutty flavour. The composition of cotton seed according to Bailey (1948) is shown below in Table 86.

TABLE 86. COMPSOTION OF SEED FLOUR

Chemical analysis	Per cent.	Minerals	Per cent.	Vitamins	Ug/g
Moisture	6·34	Phosphorus	1·26	Thiamine	10·4
Protein	57·53	Calcium	0·20	Riboflavin	10·2
Fat	6·45	Magnesium	0·65	Niacin	84·0
Nitrogen free extract	21·38	Iron	0·012	Pentothenic acid	25·5
Fibre	2·06				
Ash	6·24				

Dr. Breese Jones (1944) gives the following official comments regarding potentiality of cotton seed flour in foods.

> "The high protein content of cotton seed flour is excelled by only a few other foods. The digestibility of the total protein of cotton seed flour is as good as that of peas, 80 per cent. that of meat and 90 per cent. that of cereals. The protein of cotton seed flour is a good source of the nutritionally essential amino acids. It has growth promoting value approximately 4·5 times that of wheat crop. It is well situated to supplement the proteins of certain foods, particularly, those of cereal grains, chiefly wheat, as wheat flour is known to be deficient in some of the essential amino acids, which are abundant in cotton seed flour. Addition of as little as five parts of cotton seed flour to 95 parts of wheat flour produces a mixture containing 16 per cent. more proteins than wheat flour alone, and a protein combination definitely superior in its growth promoting value to the same quality of protein from wheat flour."

Byadagyan *et al.* (1947) after a series of experiments concluded that cotton seed flour is non-toxic for human beings, when consumed in small quantities. Kuppuswamy *et al.* (1946) on substituting cotton seed and sesame flours in South Indian diet, found marked improvement in growth in rats.

Cotton seed meal, therefore, is increasingly being used in the United States in preparation of cakes and pastries. Another cotton seed preparation, namely, 'Allison Flour', which is an admixture of wheat and cotton seed flour, is coming into increased use as human food. It is said to be 25 times as nutritive as potatoes, five times as nutritive as corn meal and four times as nutritive as oat meal.

Cotton Seed Oil as Human Food and Its Other Uses. Refined and hydrogenated cotton seed oil is manufactured on a large-scale in India. It is used as a cooking medium because of its high smoking temperature for vegetables, *dals* and for frying *puries* and sweets. In fact, it can be used as a substitute for *ghee* or other edible oils. It supplies about 270 calories per ounce as compared with the 115 calories per ounce furnished by proteins and carbohydrates. It excels animal fats in the proportion of essential fatty acids and is, therefore, effective in the treatment of fat-deficiency diseases. It is easily absorbed in the human system as co-efficient of its digestibility is 97.6 as against 97.0 per cent. of butter, 97.9 of coconut oil and 98.8 of rape seed oil.

Crude cotton seed oil and its low grade left-over after refining is used extensively in the manufacture of soaps.

Cotton seed, in fact, is a valuable by-product of cotton and every part of it is put to a variety of important uses and their new uses are being discovered.

PRESENT PROBLEMS AND FUTURE PROSPECTS

Increasing production further in the Northern Region is the problem of the day, which can be achieved by stepping up the yield per acre and bringing more areas under cotton cultivation.

SCOPE OF INCREASING YIELD PER ACRE

In the Northern Region the yield per acre is already the highest in India, but it is almost half as compared to other advanced countries of the world, In isolated experiments by some of the progressive growers, a very high yield (one to two bales per acre) has been obtained which indicates that there is a scope for a general increase in the yield per acre. There are mainly three causes for low yield, viz., thin stand, inadequate manuring, and neglect of plant protection measures.

It has generally been observed that crop in the field of the growers is usually thin in stand, the main reason for which is that they use low seed rate for reducing the cost of cultivation by omitting thinning operation. This is false economy, because in the event of a low seed rate the stand of the crop is thin; the distribution of seed is faulty, causing patches here and there; and seedling mortality in the young stage causes further gaps; the result being low plant population per acre and consequently a low yield. This difficulty can be overcome by educating the growers. The second cause of a low yield is inadequate manuring of the crop. It has already been stated that farm yard manure is available in small quantities, which is applied to the garden crops, sugarcane, maize or rice. Hardly any manure is left after meeting the needs of these crops and, therefore, the cotton crop is seldom given any farm yard manure. Experiments have shown that application of green manure to cotton is highly beneficial and is, in some respects, even better than farm yard manure. All efforts, therefore, should be directed to encourage this practice. The application of nitrogenous fertilizers has proved very economical. Their application in conjunction with green manuring or farm yard manure is a potent means of increasing the yield per acre. Some of the progressive growers have begun to use ammonium sulphate and other nitrogenous fertilizers, but the doses applied are very small. The recent experiments have shown that progressively higher yields and profits are obtainable with graded doses of ammonium sulphate up to seven and a half maunds per acre. In experiments conducted at Abohar and Hansi with the highest dose of fertilizer(125 lb. nitrogen or seven and a half maund ammonium sulphate) the *kapas* yield was increased from 1,279 to 2,148 lb. and from 697 to 1,558 lb. with a net profit of Rs. 220 and Rs. 217, respectively. It is apparent that by judicious heavy manuring there is good scope of increasing production.

The third cause of a low yield is the inadequacy of plant protection measures. The three chief pests of cotton in the Northern Region are pink bollworm, jassid and leaf roller. The last named two pests can be controlled satisfactorily with insecticides by the growers themselves, but as the pink bollworm is an internal feeder, it defies insecticidal control. Though it can be kept under control by application of several sprayings, yet the cost is prohibitive and uneconomical. This pest, in certain years, becomes formidable in the South-eastern and North-western zones and takes a toll of 60 to 80 per cent. of the crop and whatever produce is obtained is poor in quality. There is good scope for controlling this pest and thereby increasing the production, if laws are enacted and vigorously enforced for killing the pests in their resting stage by fumigation or heating all the cotton seed that comes out of the ginneries; fumigation of the factory refuse; deep ploughing of the fields immediately after harvesting cotton and the consuming or utilization of cotton sticks before the end of March.

SCOPE OF INCREASING ACREAGE UNDER COTTON

In the Northern Region, cotton is essentially an irrigated crop as indicated in Table 87.

TABLE 87. ACREAGE UNDER IRRIGATED COTTON IN NORTHERN REGION (1955-56)

State	Total cotton acreage	Area under irrigated cotton	Percentage area irrigated
Punjab	1,282	1,204	94
Uttar Pradesh	136	88	65
North-western Rajasthan	121	121	100
Total	1,539	1,413	91

On the whole 91 per cent. of the cotton area is irrigated, and evidently further increases in cotton acreage in the region are closely linked with the development of irrigation facilities.

In Uttar Pradesh the acreage under cotton has been on the decline during the past few years. Even if irrigation facilities are increased in that State, there are few chances for expansion of the area under cotton, because climate and soil respond better to sugarcane, which is the favourite crop with the growers there. However, the position is different in the Punjab and North-western Rajasthan. With the progress in irrigation there has been an increasing trend towards putting more area under cotton in the past years as will be seen from the data given in Table 88.

TABLE 88. PARTICULARS ABOUT INTEGRATED PUNJAB

Particulars	Area (thousand acres)	
	1949-50	1953-54
Total area of the State	30,353	30,353
Culturable area	18,819	19,108
Net area sown	16,063	16,894
Net area irrigated	6,635	7,479
Percentage area of crop irrigated	41·3	44·3
Acreage under cotton	534	898
Production (thousand bales)	270	554
Cotton acreage as percentage of irrigated area	8·1	12·1

It is evident from the foregoing data that, whereas the net irrigated area increased by 12.9 per cent. between 1949-50 and 1953-54, the cotton acreage showed an increase of 68.1 per cent. during this period. This shows the great patronage which the cotton crop has received in the Northern Region.

The Northern Region has already got a network of canals, but the percentage of the culturable area irrigated by them, in 1953-54, was 39.1. In this zone several new irrigation projects are taking shape, the most important amongst them being the Bhakra Nangal Project, Rajasthan Canal Project, remodelling of Sirhind and Western Jamuna Canals and construction of Sirhind Feeder. The new area which is likely to come under irrigation command is given in Table 89.

TABLE 89. STATEMENT OF AREAS TO COME UNDER IRRIGATION EVENTUALLY IN THE NORTHERN REGION

Particulars	Areas irrigated from existing sources (1949-50)	Areas to be covered by new irrigation schemes (including Bhakra)
Punjab	47,90,000	79,00,000*
Pepsu	18,45,000	45,00,000
Rajasthan	7,40,000	9,20,000
,,	—	33,00,000
Total	73,75,000	1,66,20,150

* Statistical Abstracts, Punjab (1947-50). Research and Reference Division, Public Relations Department, Punjab.

It will be observed from the data in Table 89, that benefits of irrigation will be extended to additional 166 lakh acres. This will raise the total irrigated area of the Northern Region to 240 lakh acres. Even if it is considered that the percentage of the irrigated area devoted to cotton remains at 12 per cent. as at present, the total cotton acreage can be expected to come to the figure of 28 lakh acres, i.e., nearly 11 lakh acres more than the highest area under cotton reached so far. Since most of the new area under cotton will be out of virgin land, it would not be an over-estimate to put extra production at eight lakh bales of ginned cotton. It will thus be observed that the potentiality of increasing cotton production by an expansion of area and provision of irrigation facilities are indeed very great so far as the Northern *hirsutum-arboreum* Region is concerned.

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I.C.C.C. = Indian Central Cotton Committee.
I.C.G.R. = Indian Cotton Growing Review.
E.C.G.R. = Empire Cotton Growing Review.
I.C.A.R. = Indian Council of Agricultural Research.

CHAPTER II

CENTRAL *ARBOREUM* REGION

INTRODUCTION

Attempts have been made recently to divide the cotton acreage of India on the basis of soil, climate, and variety into six regions, viz.: (*i*) Northern *hirsutum-arboreum* Region; (*ii*) Central *arboreum* Region; (*iii*) Southern *hirsutum-arboreum* Region; (*iv*) Central *herbaceum-arboreum-hirsutum* Region; (*v*) Western *herbaceum* Region; and (*vi*) Eastern Region.

The Central *arboreum* Region is so designated in view of its location in the country and the predominance of *Gossypium arboreum* L. plants in its cotton crop. Nevertheless, it also cultivates *Gossypium hirsutum*, both as pure crop in pockets where soil and rainfall conditions are favourable, and mixed with *Gossypium arboreum* in almost the entire region, except where seeds of pure departmental Asiatic *arboreum* strains are under distribution.

The region is roughly situated between the latitudes 16° to 26° N. and longitudes 73° to 79° E. and may be said to consist of the Mewar plains, the Malwa plateau, the Nimar valley of the Narmada basin, the entire Tapti basin lying east of the Western Ghats and the upper Godavari basin, up to its junction with Manjra, i.e., where the river enters the red soil zone of Andhra Pradesh.

The Mathio region of Saurashtra, included in the Central *arboreum* Region is an isolated pocket, and is situated in southern Saurashtra. It was originally a tract growing *Gossypium herbaceum*, but got converted to a pure *arboreum* zone after the great famine of 1899, when it was brought from Khandesh.

Administratively, the Central *arboreum* Region comprises : (*i*) Chittor, Bhilwara and Jhalawar districts of Rajasthan ; (*ii*) Indore, Ratlam, Dhar, Dewas, Ujjain, Mandsaur, Shajapur, Rajgarh, Jhabua, Sihore, Nimar (Khandwa), Nimar (Khargone) districts and Sausar, Multai and Harda *tehsils* of Chhindwara, Betul and Hoshangabad districts, respectively, of the new Madhya Pradesh State ; and (*iii*) Nagpur, Wardha, Chanda, Amravati, Akola, Yeotmal, Buldana, East Khandesh, West Khandesh, Nanded, Parbhani, Aurangabad, Bhir, Osmanabad, Ahmednagar and Sholapur districts of Maharashtra State, Gohilwad and Amreli districts of Gujerat State and Adilabad district of Andhra Pradesh.

AREA AND PRODUCTION

The Central *arboreum* Region which can be conveniently referred to as the Oomras zone of the country, plays a major role in the cotton economy

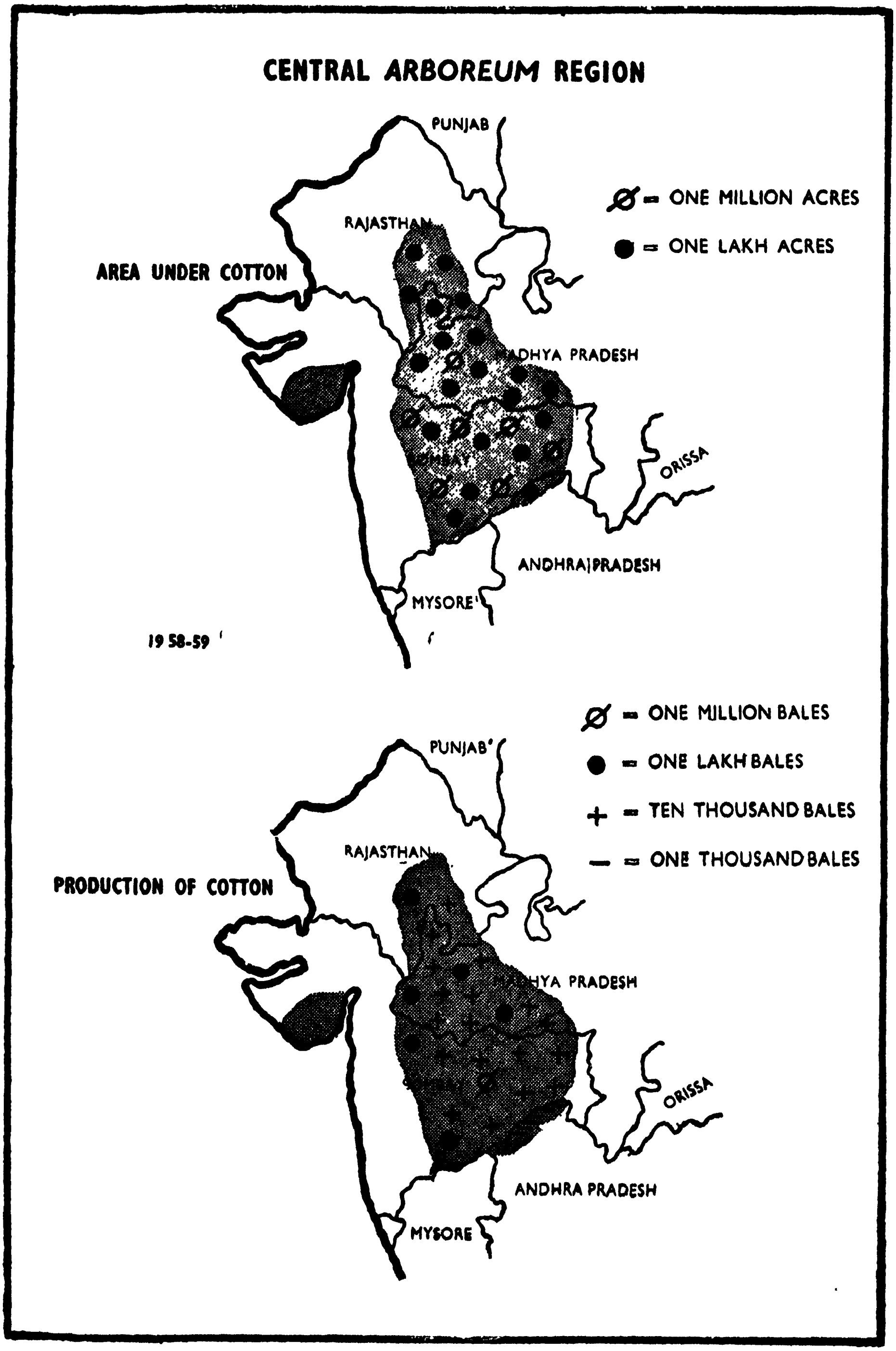

Fig. 14. Intensity of Area and Production of Cotton in the Central *arboreum* Region

of the nation. In 1955-56 it approximately produced more than 13,68,000 bales of cotton (of 392 lb. each) which constituted over 34 per cent. of the nation's production during the year. This produce came from over nine million acres, which constitutes about five per cent. of the country's area under cotton in that particular year. Table 90 gives the details of area and production in the different districts of the different States which come within the region (Figs. 14 and 15).

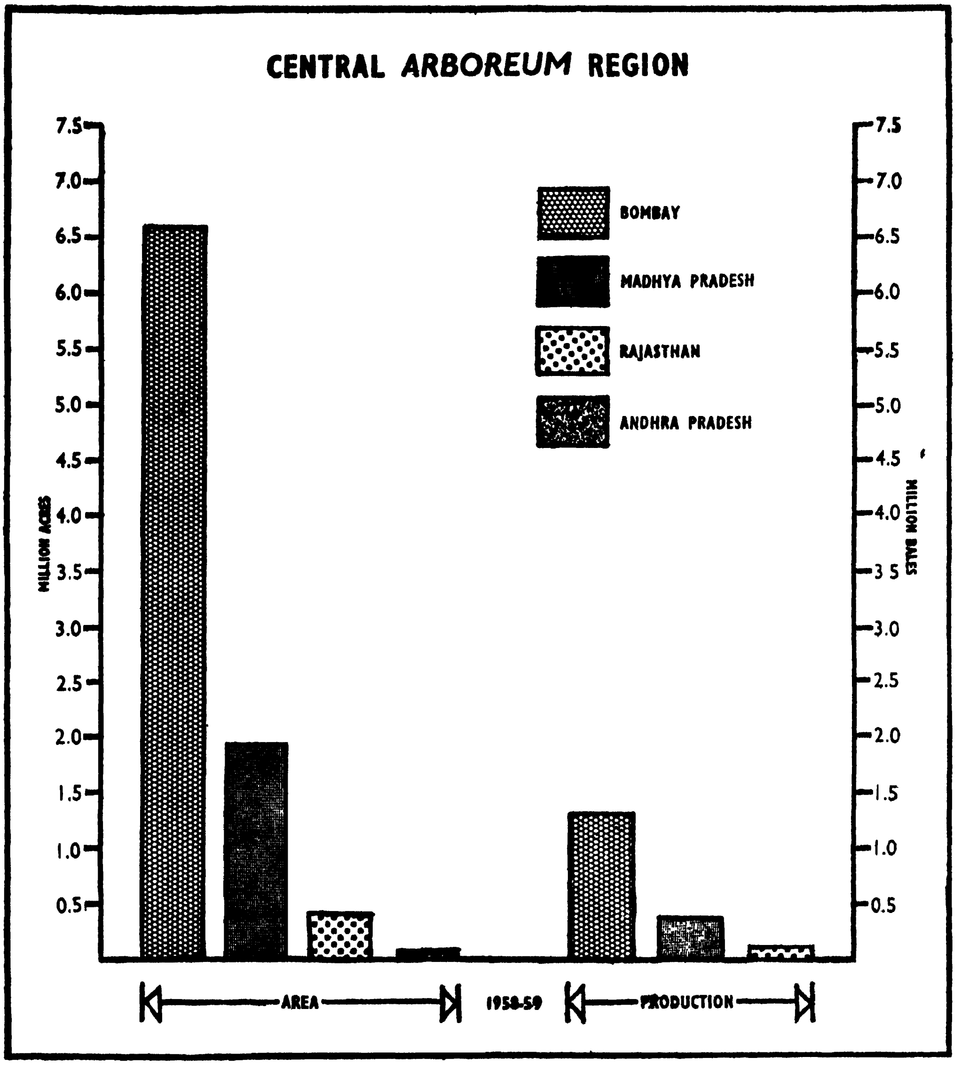

Fig. 15. Area and Production of Cotton in Different States of the Central *arboreum* Region

Area and Production of cotton during the First and Second Five-Year Plan periods is shown in Figure 16.

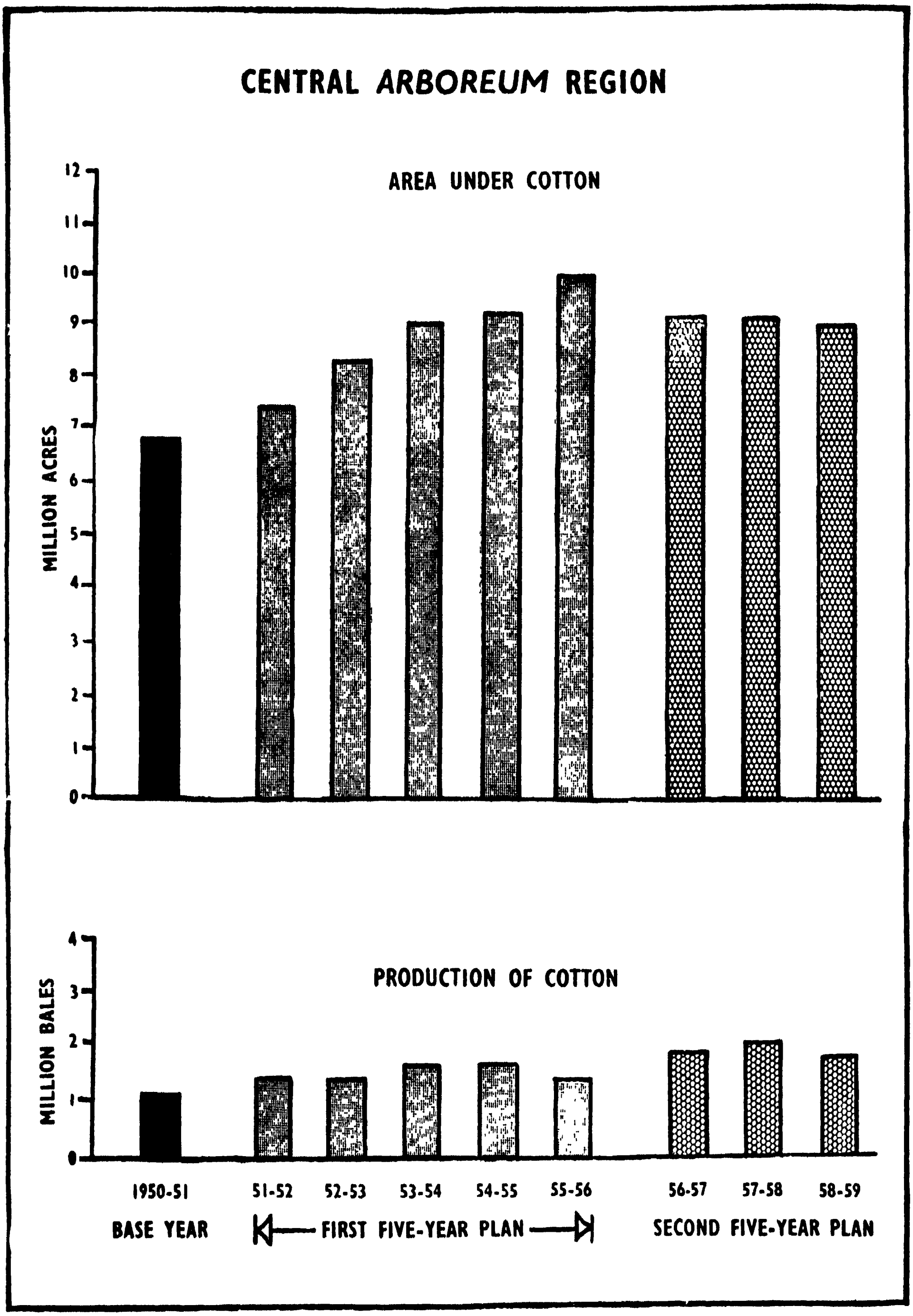

Fig. 16. Area and Production of Cotton During First and Second Five-Year Plan Periods in the Central *arboreum* Region

TABLE 90. AREA AND PRODUCTION OF COTTON IN THE CENTRAL *arboreum* REGION (1955-56)

District	Area (thousand acres)	Production (thousand bales of 392 lbs.)
Rajasthan		
Bhilwara	91	19
Chittor	100	22
Jhalawar	98	11
Udaipur	39	9
Total	328	61
Madhya Pradesh		
(Madhya Bharat region)		
Mandsaur	199	61
Jhabua	49	18
Ratlam	130	26
Ujjain	209	22
Shajapur	253	28
Rajgarh	185	63
Indore	51	10
Dewas	181	26
Dhar	155	33
Khargone	355	67
Sehore	59	7
Others	78	23
(Mahakoshal region)		
Khandwa	337	41
Chhindwara Betul	64	8
Hoshangabad	79	7
Total	2,384	440
Bombay State		
(Vidarbha region)		
Nagpur	188	14
Wardha	374	36
Chanda	39	4
Amravati	800	98
Akola	808	107
Yeotmal	656	57
Buldana	648	81
East Khandesh	669	80
West Khandesh	313	44
(Marathwada region)		
Nanded	457	37
Parbhani	567	50
Bhir	249	30
Aurangabad	592	81
Osmanabad	100	9
Bidar	173	7
Adilabad	289	24
(Gujerat region)		
Gohilwad	157	37
Total	7,079	796

The region grows 98 per cent. of its crop under rainfed conditions, the irrigated area being about 2,00,000 acres, mostly in low rainfall zones of Mewar, where crop husbandry depends upon water from the wells, tanks or minor projects rather than on uncertain rains.

The Oomras cotton produced in the region was noted to be essentially a short staple one. Nevertheless, during recent years, a large area has been replaced by the improved medium staple *arboreum* and *hirsutum* varieties developed by cotton breeders. The staple-wise production of this region is shown in Table 91 (Fig. 17).

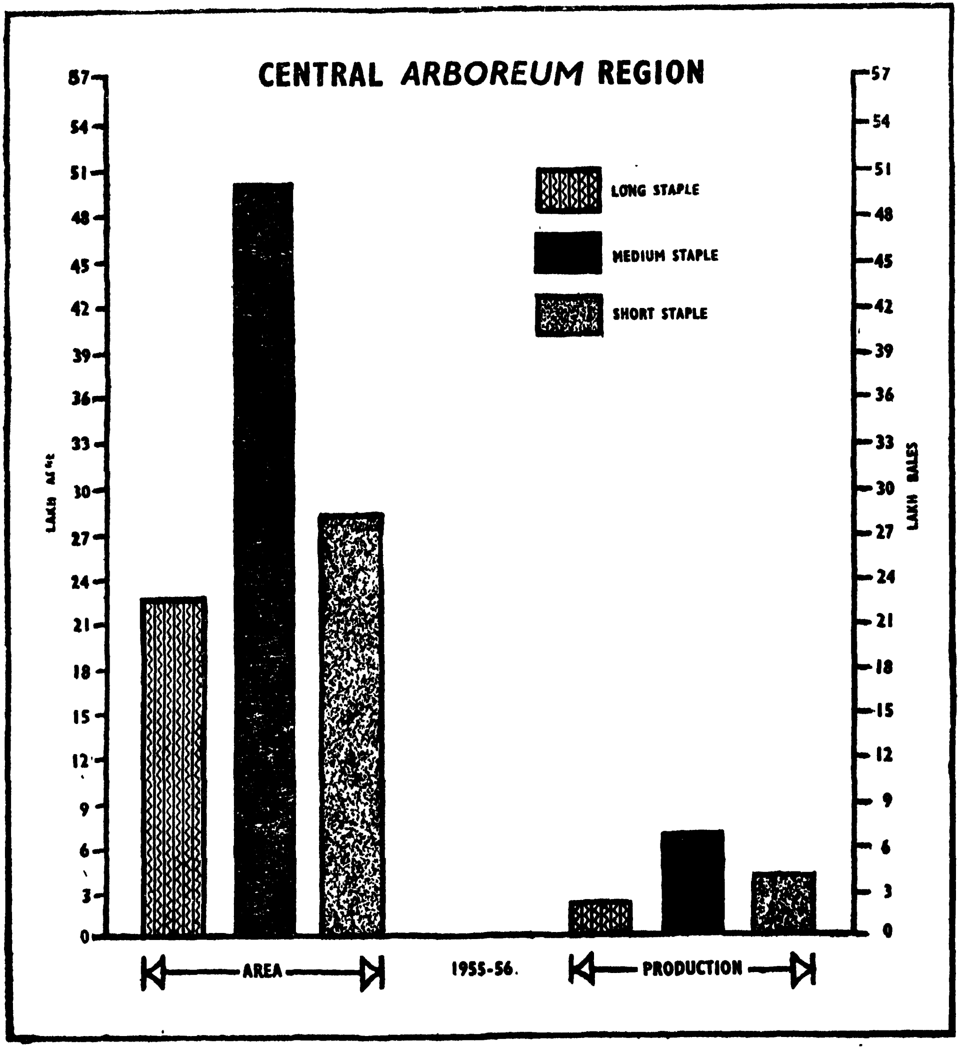

Fig. 17. Area and Production of Cotton According to Different Staple Lengths in the Central *arboreum* Region

TABLE 91. STAPLE-WISE PRODUCTION OF COTTON (1956-57) in CENTRAL *arboreum* REGION (APPROXIMATE)

Staple class	Official estimate (thousand bales of 392 lb.)				Per cent. of Central *arboreum* Region production compared to that class in whole India
	Number of bales produced	Per cent. of total production	Indian production	Per cent. of Indian production	
Superior long staple (1″ and above)	—	—	329	7	—
Long staple (7/8″ to 31/32″)	353	18	1,549	33	23
Superior medium staple (13/16″ to 27/32″)	958	50	1,539	32	62
Medium staple (below 13/16″ and above 11/16″)	236	12	599	13	40
Short staple (11/16″ and below)	373	20	707	15	52
Total	1,920	100	4,723	100	—

It will be seen that the region produces about 52 per cent. of India's short staple crop (11/16″ and below) without contributing anything to its superior long staple category (1″ and above).

SOILS AND CLIMATE

Most of the region lies below the tropic of Cancer and as such is essentially a sub-tropical area, where the length of the day is not a very big criterion in the growth and flowering of the crops.

The entire region is characterised by the black cotton soils formed from the Deccan trap of basaltic origin, their depth ranging from one to two feet in some high level regions, to several feet (may be 20) in case of low lands and velleys of rivers. The average depth of these soils may be said to be about two to four feet.

These soils, which are also known as *regur*, have a high moisture retention capacity, being loamy to clayey in texture. They develop large cracks or fissures in summer which may be sometimes three to four feet deep. The black cotton soils are further characterised by the presence of a lime (*kankar*) zone at some depth and also free carbonates ($CaCo_3$) mixed in it. They are generally rich in montmorrilinotic and beidelitted groups of minerals.

They are deficient in nitrogen and organic matter. Their potash content is variable, but generally low. These soils have a high degree of base saturation with calcium, their pH ranging from 7.5 to 8.4.

It must be realised that besides the black cotton soil, every stream or river in the region has contributed in its quota of alluvial soils. Similarly, the soils lying on hill tops tend to become light and lateritic and consequent of poor fertility.

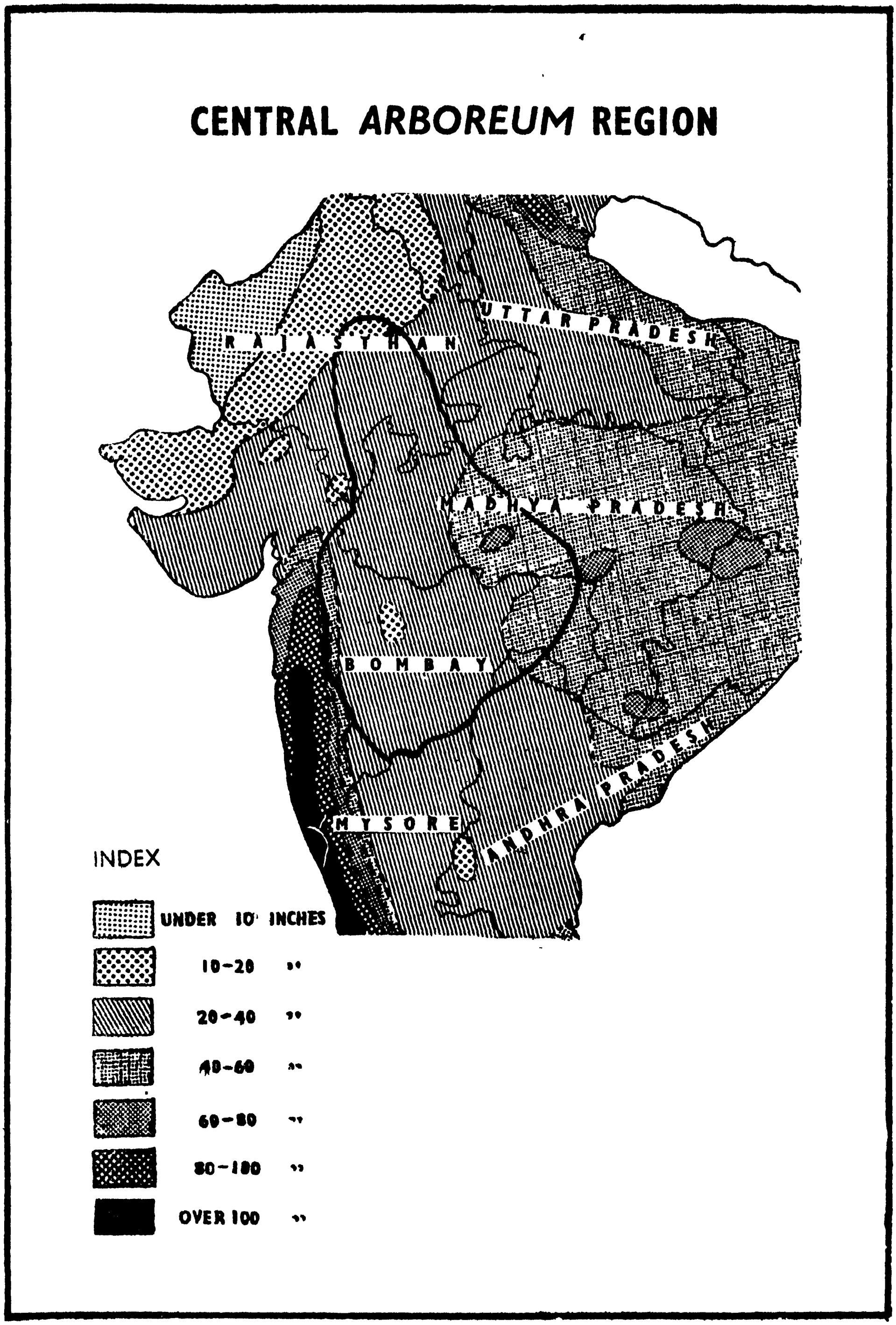

Fig. 18. Rainfall Pattern of the Central *arboreum* Region

The entire region gets its precipitation mostly from the south-west monsoon, which commences about the first or the second week of June, depending upon the distance from the Arabian Sea. It remains active in July, August and September. The north-east monsoon generally comes in a drizzle in December or early January. The period between November and May is rainless, except in some areas where ante-monsoon showers in April are a common feature.

The total annual rainfall in the region varies from 20 to 50 inches. Starting from the dry areas of Ahmednagar zone (under the immediate shadow of the Western Ghats), the rainfall goes on increasing as one proceeds east and north-east. Beyond the tropic of Cancer, i.e., north of Indore and Ujjain, it again goes on decreasing towards north-west (Fig. 18).

The region experiences three well-marked seasons, viz., moderately warm and wet season (June to September), a fairly cool winter season (October to February), and a hot dry season (March to May).

The mean daily maximum temperatures exceed 110° F. in May ; the minimum is found about 40° F. in December or early January. Frost is practically absent, except in some years in the northern portions of the region constituting Malwa and Mewar. During the cotton-growing season, i.e., from June to December, the mean daily maximum and minimum temperatures range between 87° and 65°F., respectively.

The humidity ranges from practically nil in May to 98 per cent. in July and August. It decreases from September onwards and affects boll opening.

BIO-CLIMATIC REGIONS

The topographical conditions of the country, together with variation in the mean annual rainfall from 25 to 50 inches, have resulted in the formation of distinct bio-climatic zones in the region, each needing its own adapted ecotype or variety of cotton.

The two major mountain ranges, viz., the Vindhyas and the Satpuras, and the two minor ranges of Sahyadri constituting the chain of the Ajanta, Jalna and Kinwat Hills and the Balghat range (south of Godavari) run east to west in the region. These ranges are separated from each other by broad plains, which constitute the basins of rivers like Narmada (Nimar, between Vindhyas and Satpura ranges), Tapti (Vidarbha and Khandesh, between Satpura and Sahyadri–Ajanta ranges) and Godavari (Marathwada). Besides these plains, there are : (*i*) plateaux formed by the coalescing of mountain ranges ; (*ii*) *ghat* regions in mountainous areas having thick forests ; and (*iii*) basin of the river Chambal in the north.

From the point of view of soil and climate, at least 17 such regions can be recognised in this Central *arboreum* Region, details of which are summarised here :

Plains

Generally four major plains can be recognised. They are : (*i*) Central or Vidarbha Khandesh plains ; (*ii*) Nimar valley ; (*iii*) Mewar plains ; and (*iv*) Marathwada plains.

Within these plains themselves sub-zones have been formed due to differences in the annual precipitation. These are discussed below :

CENTRAL MAHAVIDARBHA AND KHANDESH PLAINS — WARDHA-TAPTI BASIN

Nagpur-Wardha Region. The districts of Nagpur and Wardha and parts of Morshi and Chandur *tehsils* of Amravati district and Warora *tehsil* of Chanda district of Bombay State, and Sausar and Multai *tehsil* of Chhindwara and Betul districts, respectively, of Madhya Pradesh, constitute this region. It is actually the basin of the Wardha river, characterised by heavy to medium black soils and receives an average rainfall of 45 to 50 inches. The cotton variety of this area must be able to withstand not only heavy rain but resist boll shedding due to late showers.

Eastern Vidarbha Region. The plains of the Amravati and Akola districts constituting the basin of the river Purna (Vidarbha), form this region, which extends to Amravati, Daryapur, Achalpur, Murtizapur, Akola and parts of Balapur *tehsil* of these two districts. This region is again characterised by heavy to medium soils and has a rainfall of 30 to 45 inches per annum.

Western Vidarbha Region. Malkapur, Jalgaon, and parts of Khamgaon *tehsil* of Buldana district, characterised by light to medium soils and an annual rainfall of 25 to 30 inches, constitute this zone. The conditions here are intermediate, between those of Khandesh on the west and Vidarbha on the east.

Khandesh Region. This tract is comprised of the two Khandesh districts (East and West) of Bombay State with the exception of Nawapur *taluka.* It is characterised by all the three grades of soils, viz., light, medium and heavy. The soils along the rivers Tapti and Girna are specially heavy, being sometimes 20 feet deep. The region has comparatively lower rainfall, i.e., about 20 to 25 inches or lower, most of which is received during the first two months of the monsoon.

MARATHWADA PLAINS—GODAVARI BASIN

Eastern Marathwada Region. This tract is better known as the Gaorani zone and consists of the districts of Nanded, and parts of Parbhani district of Bombay State. It is characterised by soils of varying depths and has an annual rainfall ranging between 35 to 40 inches.

Southern Marathwada Region. The Gaorani protected area comprising parts of Osmanabad and Bhir districts of Bombay State, having a rainfall of 25 to 30 inches constitutes this region. It is characterised by medium to light soils.

Western Marathwada Region. Aurangabad, Bhir and parts of Parbhani district of Bombay State, where the cotton crop was known as the Hyderabad Oomras, constitute this zone. It is also characterised by the black cotton soils of different grades, and its annual rainfall varies from 20 inches in western Aurangabad and Bhir districts to 35 inches in the eastern region of Parbhani district.

Barsi Nagar Zone. The extreme western region of the Marathwada plains, under the shadow of the Western Ghats forms a specially low and precarious rainfall area, where coarse cottons known as Barsi Nagar Oomras are grown. The south-western monsoon skips the height of the Western Ghats and, as such, the zone has usually less than 20 inches of annual precipitation. It consists of a long, narrow strip running over parts of the Sholapur, Osmanabad, Ahmednagar and Aurangabad districts. The soils here are of varying depths, and predominantly light.

NIMAR (NARMADA VALLEY)

The low lying plains situated between the Vindhya and Satpura ranges —the Narmada valley extending from Handia (Hoshangabad district) in the east to Rajpur (Nimar—Khargone district) in the west—are usually referred to as Nimar. It is a narrow strip ranging from 40 to 100 miles in width running east to west, 700 to 900 feet above sea level characterised by well-drained medium black cotton soils. It could be broadly classed into two zones, viz., eastern and western, on the basis of rainfall.

Eastern Nimar. The Harda *tehsil* of Hoshangabad district and Harsood and Khandwa *tehsils* of the Nimar (Khandwa) district of Madhya Pradesh, may be considered to constitute this area. It is characterised by fairly deep to medium soils and has a mean annual rainfall of 30 to 35 inches.

In recent years, the cotton acreage in the zone, particularly in the Harda *tehsil* has been considerably reduced due to lack of labour, and a lot of good land went out of cultivation earlier as a consequence of depression of 1928.

Western Nimar. The Nimar (Khargone) district, together with Manawar and Kukshi *tehsils* of Dhar State constitute this region. It is characterised by medium soil and lower rainfall, compared to the eastern Nimar, of about 25 to 30 inches per annum. The rainfall decreases as one proceeds west. It cultivates cotton on about three to four lakh acres annually, producing over a lakh bales.

MEWAR PLAINS

Mewar Plains. The plains of Mewar lying between the two hill ranges, radiating north-east and south-east from Udaipur and drained by the river

Banas and its tributaries like Gambhir and Berach, constitute an important cotton-growing area of Rajasthan. It receives an annual rainfall of 20 to 25 inches and is characterised by heavy to light black cotton soils which grow both *rabi* and *kharif* crops. Cotton is grown in the *kharif* season, a major portion of which is sown under light irrigation obtainable from the large number of wells constituting the backbone of Mewar agriculture.

MATHIO REGION

Mathio Region. The plains of Saurashtra, lying south of the Girnar ranges and comprising a small part of the Dhanduka *taluka* of Ahmedabad district and Amreli, Sorath and Gohilwad districts of Rajkot Division of Bombay State constitute the Mathio region. The pre-War crop area in this region was about a lakh acres, producing 75,000 bales. The soils of the tract are shallow, varying in depth from one foot to four feet or more, and are medium black with a sub-soil of murum. The rainfall of the tract is low, the average being about 20 inches. The temperatures range between 36° F. minimum in January and 116° F. maximum in May.

Plateau

Malwa is by far the largest plateau of India, with an elevation of 1,800 to 1,900 feet above sea level, situated practically in the centre of the country. It is characterised by deep to medium black cotton soil and comprises the districts of Indore, Dhar, Dewas, Ujjain, Rajgarh, Shajapur, Ratlam, Mandsaur and Sehore of the new Madhya Pradesh State and the districts of Kotah, Jhalawar and Chittor of Rajasthan. It is bound on the north by the Mukundwara ranges running from Chittor to Chanderi and in the south by the Vindhya escapement. The two arms of Vindhya, running north-east, one from Vidishia to Chanderi and the other from Amjhera to Chittor form the eastern and western boundaries of the plateau, respectively. The climate of this region is temperate, the average annual rainfall ranging between 30 and 40 inches obtained mostly during June to September from the south-west monsoon, although small drizzle in January from the south-east monsoon is a regular feature. Frost is not uncommon. The plateau cultivates cotton on about 12,50,000 acres and could be demarcated into two well-marked areas.

South-West Malwa. This is commonly called as the Indore-Badnawar zone and is characterised by heavy soils and a rainfall of 35 to 40 inches. Cotton of the *Gossypium hirsutum* variety has been acclimatised in the area to grow on well-drained *adhan* lands originally used for poppy. The region comprises parts of Ratlam, Dhar, Jhabua, Indore and Ujjain districts of the new Madhya Pradesh State and cultivates the so-called Madhya Bharat-American or Dhar-Cambodia on over 50,000 acres annually.

North-East and Central Region. This is the main cotton region of the plateau and is characterised by medium to heavy soils, the annual rainfall ranging from 30 to 35 inches. It consists of Dewas, Shajapur, Rajgarh, Mandsaur and Sehore districts and the eastern part of Ujjain district of the new Madhya Pradesh State ; Jhalawar and parts of Kotah and Chittor districts of Rajasthan State. It cultivates Malvi, which is mostly *desi* cotton, on about 12 lakh acres.

Aurangabad Plateau. The Ajanta plateau lying in the northen portion of Aurangabad district is at an altitude of 1,800 feet above sea level. The area has an assured annual rainfall of 35 to 40 inches. Well-drained, heavy, medium and light soil has been found suitable for the growth of the American cotton belonging to *Gossypium hirsutum* on an area of about 2,00,000 acres.

Adilabad Plateau. Kinwat and Baoth *tehsils* of Nanded district of Maharashtra State and also parts of Adilabad district of Andhra Pradesh constitute the plateau on the eastern end of the hill ranges that run from Ajanta to Adilabad. Here again, the soils are well-drained ,and heavy in texture, the annual rainfall being about 45 inches. This area has also been cultivating American cotton belonging to *Gossypium hirsutum* for the last 20 years or so, its entire cotton acreage amounting to 2,00,000 acres annually.

Ghats (Hill Tracts)

Besides the above plains and plateaux there are distinct Ghat or hill regions where the cotton crop is cultivated in valleys, or ravines having heavy and well-drained soils and also on light soils on slopes. The rainfall in these regions is again particularly high because of their location in the midst of forests. The two mountain ranges, viz., Satpura and Sahyadri-Ajanta Ranges which run east to west in the Central *arboreum* Region constitute two zones. They are as under :

Satpura Ghats. Two of the seven Satpura ranges, viz. : (*i*) Ashiragdh in Burhanpur *tehsil* of Khandwa and Bhikangaon and Sendhawa *tehsils* of Khargone district in Madhya Pradesh ; and (*ii*) Melghat, Achalpur and Morsi *tehsils* Amravati district in Maharashtra State constitute a region which is highly suitable for the cultivation of American cottons.

Yeotmal Ghats. As already mentioned, the Sahyadri Hill ranges separating the catchment areas of the Tapti and Godavari run from west to east from Ajanta through Jalna to Kinwat and Adilabad. Their folds and slopes constitute the cotton regions of Yeotmal district, Basim and Chikli *talukas* of Akola and Buldana districts. Here the soils are light to medium in texture and the annual rainfall increases progressively eastward and ranges from 30 to 40 inches. The cotton grown in this region is mostly *desi*, the Jadi Mixture. American cotton is getting popular in the narrow valley of Painganga river, which flows along the borders of Marathwada and Vidarbha.

COTTON CULTIVATION

CROP PATTERN

The entire cotton crop of the region is grown during the *kharif* or *shallu* season, i.e., sown in May-June and harvested by December-January. More than 98 per cent. of it is sown under rainfed, i.e., dry or *barani* conditions. It is only in the Mewar plains and in the adjacent district of Mandsaur, where an acreage of 2,00,000 acres is sown under well-irrigation about four to six weeks before the advent of the monsoon. In the rest of the region, i.e., Marathwada, Vidarbha, Khandesh, Nimar, Malwa and Saurashtra plains, plateaux or Ghats, the entire crop is grown without irrigation except in small scattered garden plots.

CROP ROTATIONS

Cotton crop in the region is commonly rotated with sorghum, i.e., *jowar*. The following two- or three-course rotations are commonly adopted, depending upon the nature of the soil and rainfall in the area :

(*a*) Two-course :
  - Cotton-*kharif jowar*
  - Cotton-*bajra-sesamum*
  - Cotton-groundnut
  - Cotton-wheat
  - Cotton-gram
  - Cotton-*rabi jowar*

  The *rabi* crops may be preceded by a catch crop like *mung* or a green manure crop

(*b*) Three-course :
  - Cotton-*kharif* or *rabi jowar-groundnut*
  - *Jowar*-cotton-wheat

In the Mewar area, where cotton is grown under well irrigation, the common two-year rotation is maize-wheat-cotton-*methi*.

Rotational experiments carried out at Akola for Vidarbha regions have shown that a two-course rotation of cotton and groundnut was more profitable as compared to other combinations with *jowar* and, therefore, deserved recommendation. Nevertheless, in view of the importance of *jowar* in the overall economy of the cultivator, both as his own and his cattle's food, a three-course rotation of cotton-*jowar*-groundnut is generally advocated.

Similar experiments with Gaorani cotton were conducted for Marathwada conditions at Nanded and the results (Bederker and Joshi, 1954) indicate that a three-course rotation of cotton-*kharif jowar*-groundnut was more profitable than a two-course system consisting of cotton and *jowar* or groundnut.

Work carried out at Indore for Malwa conditions, where a three-course system, viz., *jowar*-cotton-wheat is common, showed that when cotton was grown after groundnut, it gave 40 per cent. higher yields of *kapas* than when grown after *jowar*. On an average, the monetary return given by a four-course rotation (*jowar*-groundnut-cotton-wheat) was 26 per cent. higher than by a three-course rotation.

Similar experiments were conducted at Jalgaon for the Khandesh area and the results were of the same nature as elsewhere.

PREPARATORY TILLAGE

The methods of preparatory tillage of cotton cultivation are basically the same throughout the entire Central *arboreum* Region, as it constitutes a more or less homogeneous black cotton soil area of basaltic origin.

Preparation of land generally begins during the hot season, immediately after the harvest of the preceding *rabi* crop. In case, the previous crop happens to be a *kharif* one, preparations begin much earlier. These consist of a deep ploughing, with a *desi* plough, once in three to six years, depending upon the condition of the land, some time after the middle of April (*ugadi*, *gudipadwa* or the first of *chaitra*) or immediately after the harvest of the preceding crop. Besides this, the other preparatory tillage operations for cotton in the region consist of two or three *bakharings* (harrowing with a blade harrow), once in April and then another just after the break of the south-west monsoon sometime in June. At the time of the first *bakharings* in April, advantage is taken of any ante-monsoon showers, even to the extent of giving extra *bakharings* in case they fall after the first one. This completes the seed-bed preparation in the entire region, where the tillage implements, a wooden plough and blade harrow (*bakhar*), are more or less uniform for the region.

Experiments for increasing efficiency by effecting variations in the frequency of ploughing operations, were conducted at Akola. It was found that ploughing once in three years with manuring gave higher yields. However, under unmanured conditions, ploughing every year or in alternative years was found preferable.

Gadkari and Joshi (1946) found that variations in the frequencies of *bakharings* and ploughing for preparatory tillage of cotton to be grown after either groundnut, *kharif* or *rabi jowar*, did not improve the *kapas* yields of cotton at Nanded in Marathwada.

Experiments at Indore have also shown that there is no advantage in deep cultivation by a country plough prior to cotton sowing or after the harvesting of the previous crop.

SOWING TIME AND METHODS

All the rainfed or dry cotton crop of the region is sown with the break of the south-west monsoon in June, the exact time of sowing varying with the actual arrival of the monsoon rains in the tract. It is the earliest in Khandesh and progresses north-east and east. Generally speaking, all *barani* sowings of cotton in the Central *arboreum* Region are completed within one month, i. e., between June 10 to July 10.

The irrigated cottons grown in Mewar and in isolated places in the rest of the region, are sown sometime after the middle of May and irrigated every week till the advent of the regular south-west monsoon. In case the late rains fail, they are watered in September-October.

The cotton seed is invariably plastered with cow-dung and ashes before it is sown. This operation is necessary to ensure its passage through the seed drill lest the fuzz on the seed cause any obstruction.

Cotton is sown in lines in the entire Central *arboreum* Region except in Mewar, where it is still sown broadcast.

Line sowing is done with the help of a seed drill called *mogha* or *tiffan*, the latter having three coulters and the former a single tube. There are also two-coultered seed drills in use.

In Màrathwada, where the soils are generally heavy, sowing is done through the *mogha* (single tube), fastened with a rope to the blade harrow and guided by human labour along the furrow made by the edge of the blade of the *bakhar*. Occasionally, two such drills are fastened to either end of the blade of the *bakhar*. These are also referred to as *sartas* or *nai*. In areas with medium to lighter soils like Khandesh and Nimar, two- and three-coultered drill (*tiffan*), respectively, are used. In such cases the seed is covered by running an inverted blade harrow. In Malwa, this operation is done by running a wooden log or plank called *pattra* or *patla*.

The distance between two rows varies from one to two feet in the region. It is 12 to 22 inches in Marathwada, 18 inches in Khandesh and Vidarbha, 14 inches in Malwa and Nimar and 18 to 24 inches in Mathio The distance between rows naturally varies with the depth of the soil and rainfall conditions in the region. The distance between plants within the rows is 9 to 12 inches for American cotton.

In the Mewar region, the seed is sown broadcast either after irrigation or sometimes under dry condition followed by irrigation.

Seed Rate. The general seed rate of cotton sowing in the region ranges from 10 to 24 lb. per acre. It is 15 to 20 lb. in most areas. The seed rate for *Gossypium hirsutum*, i.e., American cotton, particularly for fuzzy varieties, is generally less, i.e., 7 to 10 lb. per acre. In Mewar, the seed is broadcast at the rate of 20 lb. per acre.

Spacing and seed rate experiments conducted in Vidarbha at Akola have shown that the highest yields for *desi* , i.e., indigenous Asiatic cottons are obtained when the distance between rows is 18 inches and between plants within the row is six inches for manured and nine inches for unmanured conditions, respectively. For Buri or American cottons, belonging to *Gossypium* *hirsutum*, a spacing of 24 inches × 12 inches was found to be optimum by Bhatt and Kumbhare (1956).

Bederker, Shaligram, and Kapadnis (1956) found that the variations in spacing of rows, from 12 to 18 inches, did not materially affect the yield of Gaorani cottons in Marathwada.

Mention may be finally made of the *choufuli* method of sowing which is becoming popular in parts of Vidarbha. It involves the running of a 14 inch drill twice, once along the field and again across it, at right angles to the first, the seed being dibbled at the points of intersection, so that the plants are equidistant from one another, i.e., 14 inches between and within the rows. This method has an advantage of facilitating inter-cultivational operations in both directions.

The *desi* cotton in the tract is grown as a pure crop or mixed with *tur* (*canjanus indicus*) or even *kharif jowar.*

In Vidarbha, one to four rows of *tur* are planted after every 12 to 20 rows of cotton, the between-row-spacing for both the crops being the same. Similarly, paired rows of *tur* are planted for every 10 to 24 rows of cotton in Marathwada, Khandesh and Nimar.

Sesamum, *ambadi* (*Hibiscus cannabinus*) and *mung* (*Phaseolus mungo*) and *kharif jowar* are also planted mixed as minor crops. Occasionally, they may be broadcast in a cotton field. In southern Malwa, viz., in the Dhar-Badnawar region, Cambodia cotton (*Gossypium hirsutum*) is sown mixed with maize, the seed being mixed in the ratio of 2:1 by weight and mixture sown through the seed drill at the rate of 24 lb. to an acre. This practice reportedly benefits both cotton and maize.

INTERSEASONAL CULTIVATION

As a general rule, no thinning is done for cotton in any part of the region. When the cotton crop is about six to eight inches tall, it is hand-weeded with a *khurpi*, (a kind of hand hoe), this operation being usually known as *nidai.* One more similar weeding may be given a month later, but this is not very common. Instead of this, a bullock hoe, called *daura* or *kolpa* which resembles a blade harrow with an eight-inch blade is run a couple of times or more between the lines, as an interseasonal operation. In Malwa, the Institute of Plant Industry, Indore, has developed an Indore Ridger which puts in ridges between rows to facilitate drainage in heavy soils receiving rainfall in torrents.

Cultivation operations for cotton usually cease after the plants have started flowering, i.e., sometime in September.

Experimental work in connection with the effect of different frequencies of intercultivation operations on the yield of Gaorani cottons at Nanded showed that only one weeding was sufficient under normal conditions and that the *khurpi* was the more efficient tool for the operation as against either *daura* or the Indore Ridger.

MANURING

Prior to 1950, it was not common to manure cotton in the Central *arboreum* Region, where it is grown under rainfed conditions. During the last few years, however, following a drive for the production of more cotton, cultivators are being persuaded to broadcast ammonium sulphate at the time of sowing at the rate of 100 lb. per acre.

Fields, where cotton is to be grown, are sometimes subjected to sheep penning. Farm yard manure or oil cake is generally added to the previous rotation crop. The crop, however, is invariably manured at the rate of 40 lb. of nitrogen per acre when grown under well irrigation.

Experimental work on the nature, source, amount and the methods of application of the various manures has been conducted in the different centres in the region.

A review of earlier manurial trials of cotton conducted prior to 1940 by Panse showed that both irrigated and rainfed crops gave a universal response to nitrogenous fertilisers, especially ammonium sulphate and organic manures, like oil cakes of groundnut, *toria* and *neem*, except under conditions of soil salinity or inadequate rainfall. There was definite evidence to show that the response to nitrogenous manures as judged by the *kapas* yield was directly correlated to soil fertility. A fresh series of experiments were conducted during 1943-48 on modern lay-out with a view to studying: (*i*) efficiency of nitrogen in the form of ammonium sulphate and groundnut cake ; (*ii*) comparison of drilling and broadcasting as methods of application ; and (*iii*) nature and relationship between the quantity of nitrogen and the response obtained. As a result of 62 experiments conducted at eight centres in the black soil region, it was concluded by Panse and others that there was no difference in response between ammonium sulphate and groundnut cake except under conditions of high fertility, when ammonium sulphate gave a higher yield. The method of application made no difference with ammonium sulphate, which may be broadcast, but groundnut cake was better when drilled under conditions of high fertility and for large applications. Lastly, the rate of increase in yield per unit quantity of nitrogen increased with increasing fertility.

Thus, the findings and conditions of the above statistical studies have confirmed that the response of the crop to the amount of nitrogen applied depended on the depth-*cum*-fertility of the soil and rainfall of the region. In areas of lower but assured rainfall, like Khandesh, western Vidarbha, etc., 20 lb. of nitrogen gave the optimum yield of *kapas*, i.e., an increase of about 100 to 120 lb. per acre. With increased rainfall as in eastern Vidarbha, Gaorani area and southern areas of Malwa plateau and heavy soils of the region as a whole, the cotton crop responds to even 40 lb. of nitrogen with an increased yield of about 200 lb. per acre.

Phosphate generally proved ineffective if applied alone, but showed increases in yields when combined with nitrogen.

Increased yields from fertilisers were obviously due to more vigorous growth of the plant, better height, and greater production of flowers and bolls. The crop also showed earlier maturity.

HARVESTING

Harvesting of cotton, i.e., picking of seed cotton from bolls on the plant is carried out exclusively by human labour. Usually, the entire operations are completed in three pickings at monthly intervals during the period October to January. The picking periods for the different areas of the region go with the time of sowing of that particular area and are shown in the Table 92.

TABLE 92. TIME OF COTTON SOWING AND HARVESTING IN CENTRAL *arboreum* REGION

Area	Time of sowing	Time of harvesting
Vidarbha	Middle of June to beginning of July	October to January
Marathwada	Third week of June to first week of July	October to January
Khandesh	Second to third week of June	October to December
Malwa	Third to fourth week of June	Middle of October to middle of January
Nimar	Third week of June	October to end of December
Mewar	Last week of June to first week of July	November to January

VARIETIES GROWN

PRESENT POSITION

A list of the commercial varieties grown at present in the Central *arboreum* Region together with their staple characters and the districts in which they are grown is given in Table 93. Four of these varieties, viz.: (*i*) Madhya Pradesh-American, consisting mostly of Buri strains; Buri 107 and 0394; (*ii*) Hyderabad-American, constituted by Parbhani-American 1; (*iii*) H. 420; and (*iv*) Hyderabad-Gaorani, consisting of Gaorani 6 and Gaorani 12 having a staple 7/8″ and above, belong to the long staple category. The other five varieties, viz., Madhya Bharat-Americans, Jarila, Nimar, Verum and Malvi belong to the medium staple class with a staple range between 11/16″ to 27/32″. The remaining categories of Oomras, viz., Madhya Pradesh, Madhya Bharat, Hyderabad, and these together with Barsi Nagar, Mathio of Saurashtra and Rajasthan Desi constitute the short staple category, i.e., having a staple below 11/16 of an inch.

TABLE 93. VARIETIES OF COTTON GROWN IN THE CENTRAL ARBOREUM REGION

Variety of cotton	Staple length (32nds inch)	Tract in which grown
Madras Cambodia Uganda 1 (Rajapalayam)	32 to 34	Sholapur and Ahmednagar districts of Maharashtra State
Buri American (including 107 and 0394)	28 to 30	Amravati, Wardha and Yeotmal districts of Maharashtra State; Manawar and Kukshi *tehsils* of Dhar district, Nimar-Khargone and Nimar-Khandwa districts of Madhya Pradesh
Hyderabad Gaorani (including G·6 and G·12)	28 to 30	Nanded (except Kinwat *taluka*), Parbhani and Osmanabad districts, Mominabad *taluka* of Bhir district of Maharashtra State; Nirmal *taluka* and Mudhol, Bhainsa and Kuber Circles of Adilabad district of Andhra Pradesh
H·420	28	Nagpur, Wardha, Akola, Amravati and Yeotmal districts of Maharashtra State; Nimar-Khandwa district of Madhya Pradesh
Parbhani American 1	28	Kinwat *taluka* of Nanded district of Maharashtra State; Boath, Adilabad and Utnoor *talukas* of Adilabad district of Andhra Pradesh
C. Indore 1	26 to 28	Udaipur and Kotah Divisions of Rajasthan State
Virnar (197/3)	26 to 28	East and West Khandesh, Amravati, Akola, Yeotmal and Buldana districts of Maharashtra State; Shajapur, Ujjain, Dewas, Indore, Nimar-Khargone and Dhar districts of Madhya Pradesh; Jhalawar district of Rajasthan
Madhya Pradesh and Madhya Bharat Cambodia (including Upland)	24 to 28	Akola, Amravati, Yeotmal, Wardha and Nagpur districts of Maharashtra State; Indore, Ujjain, Dhar, Jhabua, Ratlam and Dewas districts of Madhya Pradesh; Chittorgarh, Udaipur and Bhilwara districts of Rajasthan
Jarila	24 to 28	Wardha, Akola, Amravati, Buldana, Yeotmal, Ahmednagar, Sholapur, Aurangabad and Parbhani districts of Maharashtra State; Nimar-Khandwa district of Madhya Pradesh
Malvi	22 to 24	Rajgarh, Shajapur, Ujjain, Ratlam, Mandsaur, Dewas, Indore, Dhar, Sehore and Jhabua districts of Madhya Pradesh; Jhalawar district and Nimbahera and Pratapgarh *talukas* of Chittorgarh district of Rajasthan
Pratap	24 to 26	Gohilwad (Bhavnagar) and Amreli districts of Gujerat State
M. P. Oomras	18 to 22	Nagpur, Wardha, Chanda, Amravati, Akola and Yeotmal districts of Maharashtra State; Hoshangabad, Nimar-Khandwa and Chhindwara districts of Madhya Pradesh
Hyderabad Oomras	18 to 20	Aurangabad and Bhir districts of Maharashtra State; Adilabad district of Andhra Pradesh
Central India Oomras	16 to 20	Mainly in Nimar-Khargone and Dewas districts of Madhya Pradesh
Barsi Nagar Oomras	18	Ahmednagar and Sholapur districts of Maharashtra State
Mathio	16 to 18	Gohilwad (Bhavnagar) and Amreli districts of Gujerat State
Rajasthan Desi (Bengals)	12 to 16	Kotah and Udaipur Divisions of Rajasthan

VARIETAL IMPROVEMENT—PAST AND PRESENT

The course of the varietal improvement of the cotton crop of the Central *arboreum* Region could be conveniently divided into three periods, viz.: (*i*) pre-British supremacy; (*ii*) 19th century; and (*iii*) recent times.

Pre-British Supremacy Period. During the pre-British supremacy days in the country, i.e., approximately before the 19th century, the Central *arboreum* Region was exclusively growing *bani* cottons belonging to *Gossypium arboreum* race *indica* in its areas south of river Narmada. These cottons had developed from a race of *Gossypium arboreum*, having its centre of origin somewhere in the eastern coast of India (Hutchinson, 1947). The demands of the prosperous civilisations around the Godavari valley and the famous textile industry around Paithan, and also other civilisations like Bahamani and Vijaynagar resulted in the selection of cotton for fine lint, irrespective of the ginning percentage which was not of great significance in the days of hand-ginning and spinning. There is also a belief that these cottons were used in areas even north of Narmada for textile industries at Sironj.

The regions of Malwa and Mewar, lying north of the Narmada, grew perennial or semi-annual cottons of *Gossypium arboreum* race *bengalense*. Their centre of origin is in Assam and East Bengal. They were introduced to these areas as a result of cultural contacts of the Moslem rulers of northern India whose sway often extended from Gujerat to Bengal in the east including Malwa and Rajputana. It was common knowledge that the earlier rulers encouraged weavers of famous centres to come and settle within their territories as soon as they had consolidated politically. These artisans invariably brought cotton seeds along with them.

Nineteenth Century. During the earlier part of the 19th century the rise of British influence in the area coincided with the industrial revolution of Britain, and there was apparantly a great demand for the export of cotton to that country. This, together with the development of power gins, greatly aided the spread of high ginning types of race *bengalense*, inspite of their coarse nature. The situation resulted in the rapid influx, in the region, of *Gossypium arboreum* race *bengalense*. This was a mixture of four types, *verum*, *malvense*, *roseum* and *cutchtica*. It ousted the low-ginning, superior quality *bani* (*Gossypium arboreum* race *indica*), which had an added disadvantage of bad opening of bolls compared to the *bengalense* mixture, locally called Jadi. This process of replacement of *bani* continued unabated, despite efforts, till legislation was enacted in the 20th century to protect the remaining *bani* area (the Gaorani protected area). The rest of the region, Vidarbha, Marathwada, Khandesh, Malwa, etc., had by now completely switched over, to the cultivation of *Gossypium arboreum* race *bengalense*.

By the middle of the 19th century, with the emergence of America as a supplier of raw cotton to the textile industry at Liverpool, the East India

Company became interested in producing the same quality of cotton within its domain. Accordingly, large stocks of seed of American cotton, mostly belonging to the Upland-Georgian and New Orleans (Mississipi valley types) were imported and tried in 'company gardens' besides being distributed to growers. In 1840, eight American planters were brought to India, but none of them appears to have settled down in the Central *arboreum* Region.

With the annexation of the territories of Raja of Nagpur, the present Vidarbha area came under the sway of the East India Company. This area, together with the Khandesh zone, which was mostly forest land acquired from other Maratha Chiefs, formed an important cotton-producing zone under the British. Mr. Rivet Carnace was appointed as Cotton Commissioner with his headquarters at Wardha in 1866-67 for experimenting with 'exotic' varieties and establishing 'seed farms'. It was as a result of his work that the Upland-Georgian (*Gossypium hirsutum*) in the Jadi (*bengalense*) Mixture were introduced to the region.

Similar efforts, with identical results, were made in Khandesh by Dr. Forbes (1863-74) and by Mr. Wade (1942) in Malwa.

Finally, in 1879-98, Mr. Mollison came to the conclusion that the exotic varieties of *Gossypium hirsutum* species were not suited to Indian conditions and that the hope of improvement of Indian cotton lay in the selection of indigenous varieties.

It is likely that this decision was a result of political policy, as Manchester was taking up the manufacture of higher counts from cottons of the United States and Egypt. The Indian textile industry, which had obtained a footing by now, was forced to confine itself to lower counts.

Thus, at the dawn of the 20th century, the cotton crop in the Central *arboreum* Region consisted of a mixture of varying proportions of *Gossypium arboreum* race *bengalense*, *Gossypium arboreum* race *indica* and *Gossypium hirsutum*. In certain restricted localities, however, due to the isolation resulting from poor communications, local varieties like Gaorani-Bani and Malvi were still holding ground due to the practice of hand-ginning in the respective areas.

Recent Times. The first few years of this century saw the establishment of regular departments of agriculture in important States.

The Department of Agriculture of Bombay and Central Provinces and Berar started selection and breeding work on cotton at Dhulia and Nagpur, respectively, and concentrated on the improvement of the local variety with a view to giving a higher cash return to the grower.

Subsequently the First World War and the economic stress resulting from it, spotlighted the need for improving cotton production in the country. Consequently steps were taken by the Government to establish the Indian Central Cotton Committee in 1923 to promote research and development. Intensive cotton improvement programmes were launched under the stewardship of the Committee.

A review of this work, so far as the Central *arboreum* Region is concerned, is briefly summarised below :

Bombay Presidency (Bombay State) : Work on the improvement of the present day Khandesh and Barsi Nagar tracts began in right earnest by the Department of Agriculture at Dhulia in 1921. A strain N. R. 6 was evolved by unit selection in local material and released for general cultivation in 1926. It was on a par with the local variety in the matter of *kapas* yield, staple length and lint quality, but ginned 40 per cent. against 35 per cent. of the local variety.

Work was further continued, with a large number of cultures developed from a cross of Bani × Comilla made at Dhulia in 1908. During 1926-32, this material was critically examined and a new strain called Banilla was evolved. It was superior to N. R. 6 in the matter of lint quality and length of staple, but equal to it in the yield of *kapas*. It fetched a better cash return to the grower in spite of its lower ginning percentage than N. R. 6 and as such was released for general distribution in the entire Khandeh and Barsi Nagar areas in 1932. It covered an area of 1,00,000 acres in 1937.

Complaints were, however, received against its susceptibility to *Fusarium* wilt. Further research work was, therefore, continued to develop a wilt-resistant variety. For this purpose, the venue of work was transferred to a Jalgaon farm which had facilities of heavy wilt-infected soils. As a result of six years of sustained work, a resistant type N.V.56-3, subsequently named Jarila was developed in 1943 from the *verum* material originally obtained from Central Provinces. The new strain was both wilt-resistant and superior in spinning quality. It yielded as much *kapas* as Banilla and had a ginning percentage of 35.

Table 94 gives the characteristics of the various Khandesh strains, which held the field from time to time in the entire area, including the Barsi Nagar zone.

Table 94. Characters of Different Strains Grown from Time to Time in Khandesh and Buldana

Strain	Pedigree	Yield of *kapas* (lb. per acre)	Ginning percentage	Staple length	Spinning value (H.S.W.C.)	Wilt mortality percentage
N.R. 6	Selection	615	40·0	0·68	6·0	60
Banilla	Bani x Comilla	676	38·5	0·75	16·0	60
Jarila	Selection in V. 262	739	35·0	0·84	24·0	1-2
Virnar	Jarila x N.R. 5	748	39·0	0·87	22·0	–

Baroda State (Bombay State) : The improvement of cottons of the Mathio region began in 1937 by the Department of Agriculture of old Baroda State in collaboration with the Indian Central Cotton Committee. The Mathio cottons belong to *Gossypium arboreum* race ***bengalense*** and are only very recent introductions, in the region which, prior to 1899, grew *lalio* cotton belonging to *Gossypium herbaceum* race ***wightianum***. As a result of severe famine in 1899, the entire cotton seed was lost and the seed of Khandesh cotton was imported in 1900 for sowing. It immediately established itself in the areas where the cotton soils were less retentive of moisture because of its early maturity and short duration habits as against the late and long duration characteristic of the old *lalio*. This feature has also reduced the risk of frost-damage to the cotton crop, which usually occurred once in three or four years in the area. Cotton improvement work was started at Amreli in 1937 and as a result of steady selection and testing, a strain S.31 was developed in 1947 from an original single plant selection made at Ronaj in Kodinar *taluka* (Saurashtra). It has been released under the name Pratap for general cultivation to cover the entire Mathio tract of 2,00,000 acres.

Further work to improve the defects of the low-yielding capacity of Pratap was continued and studies in progenies of the cross Jarila × C.520 showed that one selection, C.J.73 was especially promising. It has finally been developed into a true breeding strain, which not only yields as much *kapas* as Mathio but has a better ginning percentage and spinning performance than Pratap. This strain is now being recommended to replace Pratap. Table 95 gives the preformance details of the three strains Mathio, Pratap and C.J.73 (Sanjay).

TABLE 95. CHARACTERS OF DIFFERENT COTTON STRAINS OF MATHIO REGION

Strain	Yield of *kapas* (lb. per acre)	Ginning per-centage	Staple length (inch)	Spinning capacity (H.S.W.C.)
Mathio	442	30	0·72	13
Pratap	374	32	0·82	30
C. J. 73	441	34	0·90	30

Central Provinces and Berar (Bombay State and Madhya Pradesh) : The entire Vidarbha, eastern Nimar and both the Ghat regions of Satpura and Yeotmal, formed a part of the old State of Central Provinces and Berar, called Madhya Pradesh after 1948. In 1956, as a result of re-organisation, its major portion, consisting of the districts of Amravati, Nagpur, Wardha, Akola, Yeotmal, Chanda and Buldana have been included in Maharashtra State and the rest remains in the new Madhya Pradesh State.

The work of cotton improvement of Central Provinces and Berar, i.e., Vidarbha and the eastern Nirmar regions was carried out by the Department of Agriculture of Central Provinces and Berar.

As a result of their initial efforts before the First World War, Roseum was isolated from Jadi Mixture and given out for general cultivation. It immediately became popular with the cultivators because of its increased yield, higher ginning percentage and easy-to-grow nature over the Bani or local mixture, and covered practically the entire area. It was, however, later found to be highly susceptible to *Fusarium* wilt.

Work, therefore, continued with the assistance of the Indian Central Cotton Committee and a wilt-resistant strain Verum 262 was produced by selection amongst narrow yellow components of Jadi Mixture. Subsequently, in 1932, it was replaced by another strain, viz., Verum 434 which was not only wilt-resistant but also had the virtues of drought-resistance, a prolific flowering ability, low bud shedding and superior lint quality. It remained a popular variety in the State till 1944-45, its average annual area in 1950-54 being about 20.25 lakh acres.

None of these varieties reached the ginning percentage of either Jarila, the variety of neighbouring areas of Khandesh, or the earlier Roseum, which the cultivators were used to grow. Efforts were, therefore, continued to find out a better strain. Accordingly, as a result of crossing of Bani (race *indicum*) with *cernuum*, another hardy variety, a new type H.420, was evolved. It fared extremely well on the heavy and medium black soils of Akola, Amravati, Yeotmal and Nimar (Khandwa) districts, and by 1954-56 covered an area of more than 1.2 million acres.

It was realised by now that the chances of giving a *desi* (Asiatic) variety for the entire cotton acreage of Central Provinces and Berar, i.e., whole of Vidarbha and eastern Nimar, were impossible and as such efforts were directed towards the production of specialised varieties adapted for different soil and climate zones.

Accordingly, for the Nagpur-Wardha zone, a type of cotton capable of withstanding late and heavy rains was necessary. In the earlier days, late Verum was introduced, but could not make much headway due to its low ginning. Recently, a new variety, No. 91 has been developed from Bani × *cernuum* material. It yields as much as the local Jadi, gives a ginning of 37 per cent. and spins 26's H.S.W.C. Its seed is now being distributed in the area.

In Buldana or the western Vidarbha zone, characterised by medium to lighter soils and lower rainfall, a new strain M.5A or Malini, a selection in Jadi Mixture, has been developed and its seed is being distributed in the Chikli *tehsil* of Buldana district.

The Satpura Ghat tract running from Warud (north of Nagpur) in the east, to Nimar (Khargone) district in the west, has been growing American cotton of *Gossypium hirsutum* variety, wherever the soil was medium to heavy and the duration of rainfall was longer. This crop is usually referred to as the Madhya Pradesh Cambodia, although it is a mixture of Cambodia and Upland-Georgian introduced into the area by different agencies from time to time. Improvement of this cotton was carried out at Akola and Nagpur, and Buri

107 was developed by selection and recommended for use. It became very popular in Burhanpur *tehsil*, of Nimar district, and in 1954-55 the total area under it was 1,50,000 acres.

Subsequently, a further selection Buri 0394 was developed from Buri107, which had a higher ginning percentage, ability to yield better under conditions of heavy rainfall, and above all, an excellent spinning performance.

The characteristics of different strains for Vidarbha and eastern Nimar developed by the former State of Madhya Pradesh are summarised in Table 96.

TABLE 96. CHARACTERS OF DIFFERENT COTTON STRAINS GROWN IN ERSTWHILE STATES OF CENTRAL PROVINCES AND BERAR

Strain	Pedigree	Yield of *kapas* (lb. per acre)	Ginning per-centage	Mean staple length (inch)	Spinning value (H.S.W.C.)
Local Jadi	–	–	35	0·506	8
Roseum	Selection in local	–	36	0·596	10
Verum 262	do.	300	32	0·81	25
Verum 434	do.	350	31	0·87	32
H. 420	Bani x *cernuum*	–	33	0·906	31
Malini	Selection in local	–	36	0·87	34
No. 91	Bani x *cernuum*	–	36	0·85	31
Local Cambodia	–	360	32	0·84	22
Buri 107	Selection	342	28	0·87	40
Buri 0394	Selection in Buri 107	504	33	0·90	42

Hyderabad (*Bombay and Andhra Pradesh*) : The entire Marathwada region and the plateau of Aurangabad, which were parts of the old Hyderabad State, are now parts of new Bombay State. The Adilabad plateau is now included in new Andhra Pradesh.

Cotton improvement work of these tracts was till recently attended to by the Department of Agriculture of Hyderabad State. It was originally commenced sometime in 1920 with a view to keeping the quality of the fine Bani cotton, and consisted mainly of distribution of pure Bani seed to the grower. Regular improvement programme was started in 1929 under the *aegis* of the Hyderabad Botanical Scheme of the Indian Central Cotton Committee and as a result of selection in local Bani, which suffered from the handicaps of low yield, lower ginning percentage and bad opening of bolls as compared to the *bengalense* mixture which had fast infiltrated into the area from Vidarbha and Khandesh, a strain, Gaorani 6, was evolved in 1939. This strain was found suitable for the northern region of the Gaorani protected area, viz., the district of Nanded and parts of Parbhani and Adilabad districts, i.e., the eastern Marathwada region.

For the southern Gaorani protected area or southern Marathwada, another strain, Gaorani 12, was developed by 1944. Its performance was on par with Gaorani 6 but was better adapted for the districts of Osmanabad, Bidar and parts of Bhir and Parbhani districts where Gaorani 6 could not do well.

In the western Marathwada or the Hyderabad-Oomras zone, the entire area was completely overrun by 1930 by the *bengalense* mixture called Havri ousting the local Bani. Subsequently, the Khandesh strains, like Banilla and Jarila were grown by the cultivators, although they were not suited to the area. Regular cotton improvement work for the zone was started in 1942 under the *aegis* of the Hyderabad-Oomras Cotton Improvement Scheme at Parbhani. As a result of secondary selection in Gaorani 12, a new strain 2204, now designated Daulat, was developed in 1955. It has been found to be suitable for Parbhani district, which is a transition area between the eastern Marathwada (Gaorani area) and the western Marathwada (Oomras zone). It gives a higher yield of *kapas* than either Parbhani local or Gaorani 12, and has a ginning percentage, equal to the local, i.e., 35 per cent. against 31 per cent. of Gaorani 12. It has also the spinning quality of Gaorani 12.

Work is in progress to obtain strains for the plains of Aurangabad district. A selection, 1422, appears promising and is undergoing trials.

The plateaux of Aurangabad and Adilabad which used to grow the *bengalense* mixture Havri are now growing Parbhani-American, a strain of *Gossypium hirsutum* developed at Parbhani by selection in the Buri material. It was actually the Aurangabad plateau that first started growing it in 1935 or so. Subsequently, in 1939, a small quantity of its seed was taken by a private cultivator on the Adilabad plateau where it was multiplied till it covered the entire area of the plateau by 1944.

The characteristics of the different strains of Marathwada are detailed in Table 97.

TABLE 97. CHARACTERISTICS OF DIFFERENT STRAINS GROWN IN MARATHWADA

Strains	Yield of *kapas* (lb. per acre)	Ginning percentage	Staple length (inch)	Spinning value (H.S.W.C.)
Bani	300	28	0·80	29
Gaorani 6	421	32	0·85	36
Gaorani 12	311	32	0·85	32
Daulat	330	36	0·85	35
Parbahni-American 1	–	32	0·92	30

Central India — Madhya Bharat (*Madhya Pradesh*) : The tracts of Malwa and western Nimar, which are now included in the new State of Madhya Pradesh, originally formed part of the old State of Madhya Bharat, which in turn was constituted by the fusion of the princely States of Central India. The cotton improvement work of these native States, and subsequently of

Madhya Bharat, was looked after by the Institute of Plant Industry, Indore, which was established by the Indian Central Cotton Committee in 1926.

The north and eastern regions of Malwa plateau have been growing pure Malvi, the *malvense* component of *Gossypium arboreum* race *bengalense* as a secondary cash crop. After 1914, it, however, gained greater importance as the sole money crop of the cultivator due to the cutting down of poppy cultivation in the area. It, however, got mixed with *Gossypium hirsutum*, introduced in the area from time to time. As such, at the time of commencement of its improvement work in 1927, it consisted of a mixture of *Gossypium arboreum* race *bengalense* (*malvense*, *verum*, *roseum* and *cutchica* and *Gossypium hirsutum*). Its ginning outturn was 27 per cent. It had a staple 15/16" long, suitable for 14's warp. A large number of single plant selections were made in Malwa, and by 1934 a strain, Malvi 9, which gave a higher yield of *kapas*, besides possessing higher ginning and superior spinning qualities was evolved. It was recommended for general cultivation and in 1936 covered an area of 1,35,000 acres in the former Holkar State alone. During the large-scale cultivation of Malvi 9 it was noted that it suffered heavily due to *Fusarium* wilt and, therefore, efforts were directed towards finding a type which would be resistant to this disease. Accoringly, a large number of single plant selections were again made in Malvi strains and other allied material and as a result of rigorous selection and testing on wilt-sick soil, a strain Dhar 43-2 (later named Bhoj) was evolved. This strain is on par with Malvi in all economic characters and in addition has the ability to withstand the attack of *Fusarium* wilt. Bhoj was given out for general cultivation to replace Malvi in 1942.

Subsequently work was directed towards finding a strain for these regions which would gin and spin as much as Jarila and retain the yield performance of Bhoj. In order to achieve this objective, Bhoj was crossed with Jarila. A number of progenies are still under study.

The South-western Malwa or Badnawar area grew poppy (Papaver) on its *adhan* lands before the First World War. Subsequently, however, due to Government restriction on its cultivation and also as a result of experiments in 1920, it was decided to grow Madras Cambodia cotton on these lands and large quantities of seed were imported form Coimbatore (Madras) and distributed to the cultivators. This crop is now known as Dhar-Cambodia and marketed under the name Madhya Bharat-American. It is cultivated annually on an area of about 50,000 acres and has 3/4" staple, suitable for 20's warp. Work on the improvement of this crop began at Indore in 1934. By 1950, a variety Indore 2 was evolved which yields 20 per cent. more *kapas*, gins and spins better than Dhar-Cambodia. It is now being recommended for general cultivation in the area. Further work is now in progress, under the Indian Central Cotton Committee's scheme operating at Badnawar and it aims to produce a cotton which is superior to Indore 2 in staple length and spinning quality.

The western Nimar tract, constituting the Nimar or Khargone district of the new Madhya Pradesh also formed a part of the princely States of Central India. Its cotton improvement work was begun by the Institute of Plant Industry, at Dhamnod. A large number of single plant selections were made in 1934 and tested in subsequent years to produce a better strain of cotton. By the time the work was about to yield desired results, the position of the local Nimadi changed entirely due to the influx of Jarila in the tract. It was then felt that the improved strain must gin and spin as much as Jarila and should have the higher and steady *kapas* yielding capacity of the local Nimadi. Breeding was further oriented to meet this point of view. A special scheme of the Indian Central Cotton Committee was launched for it at Khargone in 1948 and as a result of its work, a new strain D.48-154, named as Maljari, was evolved. It not only yields, gins and spins better than Jarila but is superior to its successor Virnar except in the matter of ginning percentage.

As already mentioned before, about one-third area under cotton in Nimar, lying in the valleys and slopes of Satpura ranges, grows American cotton belonging to *buri* varieties, which project from the adjoining Burhanpur zone. Work was carried out to find a better adapted *hirsutum* variety for this region, and a new variety A.51-2 (a selection from Buri 0382) has been found. It has a better *kapas* yield and ginning percentage than Buri 0394 and is being further tested.

The economic characters of the strains grown in Malwa and estern Nimar (Madhya Bhrat region) are given in Table 98.

TABLE 98. CHARACTERISTICS OF COTTON STRAINS GROWN IN MALWA AND WEST NIMAR

Variety	Pedigree	Yield of *kapas* (lb. per acre)	Ginning percentage	Staple length (inch)	Spinning value (H.S.W.C.)
Local Malvi	Selection in Malvi bulk	380	28	–	12
Malvi 9		441	32	0·79	20
Bhoj		483	32	0·77	21
Dhar-Cambodia	Bulk	513	31	0·82	23
Indore 2	Selection in X-ray pedigree	686	33	0·89	29
Local Nimar	–	405	33	0·83	28
Maljari	Malvi × Jarila	576	36	0·86	30

Rajputana (*Rajasthan*) : The plains of Mewar, or the upper basin of the river Banas, formed a part of the erstwhile princely State of Udaipur (Mewar) now merged in Rajasthan. At the beginning of the 20th century, it grew only indigenous cotton belonging to *Gossypium arboreum* race *bengalense*. In 1921, Sir Chenevix Trench, Revenue Minister of Udaipur State, imported large quantities of seed of American variety C.A.9 (*Gossypium hirsutum*), and distributed them to Mewar cultivators. It fared well and spread immediately.

However, due to the lack of facilities for maintenance of its purity, it got badly mixed up and now contains a sprinkling of local Desi. This crop, locally known as Vana, has a staple length of 11/16", gins 30 per cent. and spins 12 to 14's warp.

Work on the improvement of this crop was taken up immediately after 1939 when the old Mewar State became a member State of the Institute of Plant Industry, Indore. Varietal trials conducted in the regions showed that Indore 1, a variety evolved earlier at Indore for Rajasthan conditions, gave better *kapas* yield and spinning performance than the local American Vana. It is also more hardy and early-maturing than the local Upland and as such was recommended for general cultivation. It covered 60,000 acres in 1954-55.

In 1947, the Indian Central Cotton Committee started a scheme at Udaipur to improve these cottons. Since then, three strains M.48-4, M.48-16 and M.49-398 have been developed. All of them are superior to Indore I, and are undergoing district trials. As regards the improvement of *desi* cotton grown under irrigation, it is hoped that being extremely short stapled it would be replaced by the new American strains.

The economic characters of Rajasthan varieties are given in Table 99.

TABLE 99. ECONOMIC CHARACTERS OF COTTON VARIETIES GROWN IN MEWAR

Strain	Pedigree	Yield of *kapas* (lb. per acre)	Ginning per-centage	Staple length (inch)	Spinning value (H.S.W.C.)
Vana (American local)	–	931	31	0·69	16
Indore I	Selection	990	31	0·87	26
Vani (*Desi* local)	–	—	33	0·45	8-10

PESTS AND DISEASES

The annual cotton production of the Central *arboreum* Region is greatly conditioned, both in the matter of quantity and quality, by the incidence of pests and diseases. Fortunately, the magnitude of the problems arising from this is comparatively less in the region than in areas where the crop is grown under irrigated conditions. Nevertheless, the losses caused by pests and diseases are too large to be ignored. It is difficult to give an extent of the damage caused by them, but on a rough estimate, 10 per cent. reduction in the overall production of cotton can be attributed to these factors. A brief account of the pests and diseases in the region follows.

PESTS

A large number of insect pests attack cotton in the region. Many of these, for example, caterpillars and grass-hoppers are major pests of other crops like gram, lucerne, tobacco and paddy and attack cotton as an additional or alternative line of subsistence.

The maximum damage to cotton is done by insects which feed only on cotton or malvaceous plants.

The spotted bollworm (*Erias fabia* and *insulana* Boisd), pink bollworms (*Platyedra gossypiella*) and jassids or leaf hoppers (*Empoasca devastans*) can be regarded as major pests in the area.

Among the minor ones common in occurrence are: (*i*) leaf roller (*Sylepta derogata* sp.); (*ii*) red cotton bug (*Dysdercus cingulatus*); (*iii*) mealy cotton bug (*Oxycarenus laetus*); and (*iv*) cotton semi-looper (*Tarache* sp.)

A brief description of the nature of damage, life history and control measures against these is given below.

Spotted Bollworm (*Erias fabia* Stoll *and Erias insulana* Boisd.) : It is the most important pest which destroys buds and shoots of the cotton plant. There are two species, viz., *E. fabia* and *E. insulana* which go under the general name of spotted bollworms. They are similar in size and shape except that the *E. insulana* caterpillar is characterised by a spine on the body. Both these species occur in the Central *arboreum* Region, although *E. fabia* may be said to predominate. Young worms, which have already bored their way into the succulant internodes, attack buds immediatly they appear. The affected younger shoots are characterised by drooping and fading; the buds and flowers shed. Developing bolls are attacked and in case they are not shed, they do not open. In case they open, they do not have any cotton in them. The pest attacks the growing shoots in the early stage and buds and bolls in the later stage.

The bollworms are active all round but their population is maximum during July-September.

The pest is an internal feeder and hence the methods of its control are only preventive. Crop damage due to this pest can be reduced by :

1. The destruction of affected shoots at the commencement of the growing season.
2. Complete removal of the standing cotton sticks from the field after harvest.
3. Non-cultivation of malvaceous plant like *bhendi* (*Hibiscus esculentus*) in the same area during the period between two cotton-growing seasons.

Recent trials with new insecticides like DDT and dieldrin have shown that pest can be controlled by them (Nadkarny, 1956).

Pink Bollworm (*Platyedra gossypiella* Saund.): This is another serious pest of cotton which causes much greater damage to exotic (American) as compared to the asiatic types. It is indigenous to India and its multiplication is greatly favoured by humidity and temperatures ranging between 70° to 80° F. (12° to 23° C.). It is rarely seen in the shoot of the cotton plant but causes extensive shedding of young squares, buds and bolls. The young larvae, caterpillar bore their way into these forms. The hole made for their entry heals up leaving no outward trace of the presence of parasite within the square, bud or boll.

The full-fed insect (caterpillar) enters a resting stage, generally at the end of the crop life and remains dormant till the advent of the next rainy season. It begins to emerge with the start of the south-west monsoon, the maximum emergence being in July and August. Thereafter, it continues to multiply in short life cycles of 21 to 30 days each, till the end of the season, when it again goes into resting stage in soil and seed.

Damage by pink bollworm is generally very little in the beginning of the season, when probably the spotted bollworms feed very voraciously. The pink bollworm has, however, a preference for the more developed bolls as compared to younger ones possibly because of the food material available in the seed.

The control measures recommended are :

1. Sowing of early-maturing varieties of cotton.
2. Competition in the final picking.
3. Removal of cotton sticks and plants from the field as soon as possible.
4. Ginning of all seed *kapas* eight to ten weeks before the monsoon.

Heating the cotton seed by exposing to the hot sun or passing it through Simons Heater at 60° C. is also recommended as a control measure.

Jassids or Leaf Hoppers (*Empoasca devastans* Dist.) : These sucking insects cause considerable damage to American cotton. They attack *bhendi*, potatoes, etc., during the season and cotton during June-December. The insect sucks the cell sap from beneath the leaves with the result that they point downwards, turn red and ultimately drop off from the plant, thereby considerably reducing the fruiting capacity of the plant.

No practical and economical measures seem to be known except those of developing and cultivating resistant varieties. It is noted that such varieties have leaf hairs of particular length and density such as would offer mechanical hindrance to the insect to lay eggs.

Leaf Roller (*Sylepta derogata* F.) : It is a biting insect, which destroys leaves of American cotton, particularly those grown under irrigated conditions. Damp and cloudy conditions seem to favour its development. The damage is caused by caterpillars. When young they feed on the lower side of the leaf, and when old they roll up the leaves with edges turned downwards, feeding finally on the midribs.

By the end of cropping season in February, the reddish-brown pupae are found in the rolled leaves or on the ground amongst fallen leaves, which stick together by silken threads. They pass the resting stage among the fallen leaves and flower buds, and again appear in March and remain active till November.

Bhendi (*Hibiscus* sp.) is recorded to be its alternate host.

The pest may be controlled to some extent by: (*i*) removal of alternate hosts; and (*ii*) hand-picking the rolled leaves with caterpillars, at the beginning of the attack itself.

Red Cotton Bug (*Dysdercus cingulatus*): It is another sucking insect, which is a minor pest of cotton, often causing serious damage to green bolls, the intensity of its attack being favoured by the conditions of higher humidity and lower temperatures. The bugs are generally found feeding in clusters on the developing bolls, depleting its juices and thereby stunting their growth. The bolls open immaturely and the seed produced is useless for sowing. These bugs are also supposed to be responsible for the introduction of the bacteria, *Nematospora gossypii*, into the bolls which stain the fibres.

As regards control measures, it is suggested that: (*i*) *bhendi* be used as trap crop; and (*ii*) the gregariously feeding insects be shaken down in 'kerosenised' water.

Dusky Cotton Bug (*Oxycarenus laetus* Kirby) : This is another cotton pest, which appears at the end of the cotton season and affects open bolls, destroying the lint and the seed. Both the adults and the nymphs suck juice from maturing seeds and continue to feed even after the cotton is picked. They get crushed in ginning, and stain the lint.

The control measures suggested for this pest, are the same as for the red cotton bug (*Dysdercus cingnlatus*).

Cotton Semi-looper (*Tarache notabilis*) : The cotton semi-looper is reported to cause serious damage to Mathio cotton in Amreli region. It is specific to cotton and the insect emerges from the underground with the first shower of the monsoon rain and starts feeding on the leaves of young cotton plants. Its activity and life cycle continue till monsoon conditions prevail, after which it hibernates in the soil till the next monsoon season.

Besides the above pests, the cotton crop of the region suffers from attacks of thrips (*Scirtothrips dorsalis* Hood and thrips *tabaci* L.), aphids (*Aphis gossypii*), stem borers (*Sphenoptera gossypii*), grass-hoppers (*Chrotonomus* sp. *Aiolopus* sp. *Aamdus*), gram caterpillars (*Hileothus obsoleta*), etc.

Generally speaking, it may be assumed that the American cotton crop belonging to *G. hirsutum* is less tolerant to insect attacks than that belonging to *G. arboreum*.

DISEASES

Most diseases of cotton encountered in the region are of minor importance, with the exception of *Fusarium* wilt, which affects *desi* cotton of *G. arboreum*. The American cottons belonging to *G. hirsutum* are, however, immune to this disease in the region. The latter, however, suffers largely from a non-fungal physiological disease, commonly called the red leaf. Minor diseases like root rot, dry rot (sore shin) anthracnose, stenosis, green mildew (*dahiya*) and blackarm also occur in the region. They, however, assume serious proportions only in the years of heavy and continuous rainfall.

A brief description of the different cotton diseases in the region is given below :

Wilt : Cotton wilt is caused by *Fusarium vasinfectum* Atk. It occurs practically in the entire region and particularly in Vidarbha, Khandesh, Marathwada and Malwa.

In the early stages of attack, the cotyledonous leaves may turn yellow. The foliage leaves may loose turgidity a little later. Wilting starts from the oldest leaves at the base, proceeding upwards and involving either a branch or the whole plant. The withered leaves may become yellow, and later, brown. After some time, the stem of the diseased plant starts turning brown from top downwards till the whole plant is covered. The process may be checked at any stage, and new green shoots appearing below may recover as a result of new growth, but they are dwarfed.

Seedling in the advanced stage of attack often shows at the base of the stem a discolouration of the bark, which extends to the tap root. In fully developed plants, this discolouration may not be seen, but on removal of the bark tissues below, blackened steaks or stripes are always found both at the base of the stem and the upper roots. Further, dark streaks are seen in vascular strands also.

Soil temperature has a great influence on the incidence of the disease. It is very effective between 22° to 30°C. (optimum 24° to 28°C.), decreases at 32°C. and is completely inhibited at 35°C. and above.

Although cotton wilt is known to be carried through seed, only a small percentage of the seed harbours dormant mycelium, as an internal infection. The infected seed is, therefore, not considered to be an important source of dissemination. Only when introduced into a wilt-free area, which is susceptible to the disease, does it become potentially dangerous.

None of the cultural methods are definitely known to control the disease. The development of resistant varieties alone offers the greatest promise for successfully dealing with the malady. Accordingly, Uppal (1941) developed a technique by which an artificial epidemic of cent per cent. mortality could be produced by growing the seed in artificially inoculated soil, and placing it under constant temperature tanks (24° to 28°C.). As a result of the use of this method, wilt-resistant varieties like Jarila and Bhoj, were evolved for Khandesh and Malwa regions, respectively.

Root Rot : Root rot is caused by *Macrophomina phaseoli* (Maubl.) Ashby. Butler isolated *Rhizoctonia* from cotton plants suffering from root rot, but was not able to produce it with a pure culture of the fungus. Likhite reported the presence of *eelworms* of the genus *eaphalobus* constantly associated with *M. phaseoli* and causing root rot.

The most striking symptom of the disease is the sudden and complete wilting of the affected plants. The dying plants cover circular patches.

The affected plants in many cases may recover in cool nights in the wet weather or in irrigated patches.

The whole of the root system becomes decayed and detached, so that such plants can be easily pulled out of the ground with the tap root intact. In recently wilted plants, the root is slightly moist and sticky to the touch at the tip and shows considerable shedding of bark and yellowing of exposed woody tissues. In badly affected plants, the wood may be discoloured brown or black and all the root tissues broken down into shreds. The underground portions of the wilted plants are covered with sclerotia of the fungus.

Both the fungii show marked periodicity in their parasitic activity, which is definitely related to soil moisture and temperature, the range for the latter being 25° to 40°C.

As regards methods of control, it is claimed that mixed cropping with *sorghum* and *Phaseolus aconitifolius* has a marked effect in the reduction or mortality due to root rot in cotton. Efforts to breed resistant varieties have not so far been successful.

Dry Rot or Sore Shin : The occurrence of dry rot or sore shin disease of cotton caused, by *Macrophomina phaseoli* (Maubl.) Ashby, has been reported from Vidarbha, Marathwada and Khandesh regions of Bombay State. It is very severe on heavy, water-logged soils and appears in the years of continuous heavy rains immediately after sowing, largely in early-sown cottons where temperatures are generally high.

The disease is usually confined to month old plants, although it can affect older ones also. The disease affects only the collar of the stem, roots, and leaves. Diseased plants can be easily uprooted as the affected part of the tap root is thinner than that of the healthy plants. The infected leaves become bleached and then turn yellow. Subsequently, they shrink and become crisp or brittle, and have a tendency to roll inwards.

This disease is reported to be controlled by good drainage.

Anthracnose : Anthracnose is caused by *Collectotrichum idicum.* It is known to attack cotton crops of Vidarbha and Khandesh and becomes destructive in wet years. It attacks seedling, bracts, and bolls and infected seeds as well.

It appears in the form of lesion or water-soaked spots which gradually extend and cause brown shreds on the stem. The diseased area gradually dries and damages the plant causing leaf and boll shedding. Seeds affected severely are abnormally light, poorly and irregularly developed and of brownish colour as a rule. Such badly infected seeds do not germinate.

As the organism persists in a viable condition in the seed coat, it is generally disseminated by the infected seed. Good results are obtained by seed dressing with organic mercury compounds.

Grey Mildew : The grey mildew of cotton, commonly known as *dahia* caused by *Ramularia areola* Atk., has recently become an important disease of American cotton in Vidarbha. It affects the older leaves, as the plants reach maturity, in the form of angular pale, translucent spots and with a definite margin formed by the veins of the leaf. As the spots grow older, the leaf tissues turn yellowish-brown, while a whitish frosty growth appears chiefly on the under surfaces, and occasionally above. The affected leaves are shed prematurely. The final yields are adversely affected.

As regards control measures, spraying with bourdeaux mixture or dusting with sulphur have been found to give satisfactory results.

Stenosis : This disease, characterised by its shortening of the foliar organs of the plants is caused by virus, and affects the indigenous cottons only. No control measures are known.

Blackarm : The angular leaf spot or blackarm disease caused by bacterium *Xanthomonas malvacearum* (E. E. Sm.) also occasionally occurs. The bacterium infects most of the aerial parts of the cotton plant, viz., cotyledons, leaves, stem and branches. The disease is characterised by water-soaked spots, roundish on cotyledons and subsequently by angular spots on leaves. Affected stems turn black and easily break off and die.

The infection may be both primary and secondary, the latter being favoured by heavy rains in humid weather. The bacteria within the boll pass along the fibres, infect the seed and get carried through it.

This disease mainly affects the American cottons belonging to *G. hirsutum.*

Control measures have been confined to seed dressing and the development of resistant varieties. Seed treatment with cerasan, agrosan and formaldehyde have given good results. As regards breeding for resistance, no really resistant variety is yet available.

Red Leaf or Leaf Blight : This is a very common physiological disease of the exotic, i.e., American cotton in the region. Its incidence is marked by the leaves of the plant turning yellow or red during all stages of growth. The red colour may develop in patches in the interveinous portion of the leaves. The affected leaves roll downwards and begin drying from the edges, sometimes involving the whole tissue of the leaf. The plants give a considerably reduced yield.

Investigations have shown that this condition may be caused by any factor which may be responsible for the improper uptake of the essential elements like nitrogen, phosphorous and also with such conditions as bring about impediments in the translocations of sugars. It is also often associated with jassid or aphids attacks which tamper with the translocation mechanism and its products of the plant.

Besides the above disease, occurrence of *Sclerotium* wilt (*Corticum rolfsii*) (Sacco), wet rot (*Phytophthora parasitica* Dastur) and internal boll disease (Nematospora) is also recorded in the region.

YIELD AND ECONOMICS OF PRODUCTION

Cotton is easily the most important cash crop of the cultivators of the region and as such a grower uses all his resources in its culture to obtain maximum yields with minimum cost.

The acre-cash value of cotton obtainable depends mostly on the amount of lint and seed produced, although the quality of the former plays no mean role.

Since the cultivator's crop is marketed as *kapas*, its acre-production is his measure of yield. The national production of cotton, however, is considered from the point of view of the amount of lint produced in terms of lb. of lint or number of bales, each having 392 lb. of lint.

YIELD

As already stated, 98 per cent. of the cotton crop in the region is grown under rainfed conditions. As such, the yields are generally low and vary from zone to zone depending on the amount and distribution of rainfall and the fertility level of the soil. Yields of up to 800 lb. of *kapas* are obtained on heavy, well-drained and manured soils if the rainfall has been optimum. Usually, the best yields of cotton are obtained from a well distributed rainfall ranging from 25 to 30 inches. However, in most of the areas, due to the lack of manuring, poor fertility level of the soil and the vagaries of the monsoon, the average yield levels are reduced and are as low as 150 to 300 lb. per acre.

Under irrigated conditions, with controlled supply of moisture, 1,000 to 2,000 lb. of *kapas* can be considered to be normal unless affected by other factors.

Correct estimate of yield of cotton for each district in the region is a very important matter both for administrative purposes as well as for economic planning.

During the earlier years, and even now in certain areas, the yield estimates are based on the multiplication of the acreage and seasonal factor with a figure which used to be known as 'standard yields' for the district. These were arrived at by revenue officials as a result of general experience and local opinion. These figures were very broad since they could not possibly take into account the variation in the conditions of crop culture within the district itself.

Subsequently, Panse and Kalamkar made a plea that correct estimates of *kapas* yield could only be obtained by the random sampling method which involved the regular crop cutting experiments during the season.

The Indian Central Cotton Committee and the different cotton-growing States have accepted this principle and the method is now adopted as a regular departmental procedure to estimate cotton yield.

The average district yield of lint during 1955-56 in the region is given in **Table 100.**

TABLE 100. AVERAGE YIELD OF LINT PER ACRE DURING 1955-56 FOR DIFFERENT DISTRICTS IN CENTRAL *arboreum* REGION

District	Yield of lint (lb. per acre)
Chanda	40
Nagpur	30
Wardha	38
Akola	52
Amravati	46
Buldana	37
Yeotmal	34
East Khandesh	45*
West Khandesh	55*
Ahmednagar	31*
Sholapur	82
Parbhani	34
Aurangabad	54
Nanded	32
Osmanabad	37
Indore	36
Dhar	83
East Nimar	87*
West Nimar	94
Ujjain	41
Shajapur	55
Mandsaur	54
Bhopal	35
Jhabua	105
Dewas	56
Rajgarh	108
Udaipur	269
Jhalawar	135
Chittorgarh	237
Bhilwara	247

Note : 1. All the above yields except those marked by (*) are by crop-cutting method.
2. Yields for districts of Rajasthan are under irrigated condition.

ECONOMICS OF PRODUCTION

Attempts were made in the past by various workers to estimate the cost of production of cotton in the region but the data that were collected by them referred to production on Government Farms where the yields and the wages paid to labour were generally higher. Furthermore, these enquires never gave any conclusive results because of the lack of uniform standards of holdings, wages, prices, etc.

Recently, however, Panse (1954) conducted a pilot enquiry in Akola district, a representative area of black cotton soil region, to estimate the cost of production of cotton and its rotation crops. The investigation estimated physical quantitites, such as human and bullock labour, and materials like seed and manures, required for production of cotton and its rotation crops, together with the money equivalent of these quantities. The findings of this enquiry are as given in Table 101.

Table 101. Cost of Production for Cotton and Rotation Crops in Akola

Item	Cotton	*Jowar* (Rupees per acre)	Groundnut
Man labour	10·83	14·26	12·52
Woman labour	10·00	5·21	8·05
Bullock labour	16·63	16·02	16·71
Seed	1·72	0·61	13·70
Manure	4·37	1·78	2·13
Watching	0·17	0·50	1·29
Land revenue	2·15	1·90	1·28
Rent	5·69	9·16	16·56
Implements	0·66	0·76	0·64
Total	59·92	50·11	72·91

Thus taking into consideration an average yield of 2.69 maunds (221 lb.) of seed cotton, the total cost of production per maund works out to Rs. 22.27.

MARKETING AND GINNING

Cotton is marketed as *kapas* in the region in a variety of ways, each system being guided by local customs and conventions. The sale of ginned cotton or lint directly from the grower is rare, and takes place only in the case of a few large growers, seed farms or co-operative societies dealing in the supply of pure seed.

GENERAL MARKETING

The grower may dispose of his cotton through a *bania*, *dalal* or a co-operative society either in the village proper or in a neighbouring assembling place which may be a regulated or an unregulated market.

Village Sales. Here, the cultivator is as a rule, under financial obligation to the *bania* or *dalal* and has to part with his produce at a price much below the prevailing normal rates. In some places, the *bania* buys the standing crop, in which case the estimated outturn from the field is always valued below the expected yield and also at rates lower than the prevailing ones.

This method is evidently of greatest disadvantage to the grower. All the same, the bulk of the produce of the region is marketed in this fashion. The village *bania* mixes the different lots of *kapas* and sells them to upcountry dealers who in turn sell it either to bigger dealers or to large exporting firms or ginners. The latter get the *kapas* ginned and pressed and either sell to mills or send it to places of consumption.

Unregulated Markets. Seed cotton may be taken by the grower from villages to the neighbouring town having neither regulated markets nor co-operative societies. In such places or assembling markets, the cotton carts and their owners gather together early in the morning at a fixed place which may be the yard of the ginning factory or an open space provided by merchants. The buyers and brokers also begin to assemble by noon, by which time they get information, telegraphically, on the Bombay rates. Very soon, bargaining between buyers and sellers, or more correctly between *adatiyas* and *dalals* starts. *Dalals* move about freely with samples from the carts of their clients showing them to prospective buyers. Bids are made under cover of cloth. The first price that is agreed upon is taken as the ruling price for the day, allowance being made for the difference in quality. Within an hour, the whole market is cleared and the carts are then taken to the ginning yard where they are weighed and heaped on bare ground to await its turn of ginning. Only a few factories provide godown facilities. The grower usually gets his payment by the evening and returns to his village.

The above process is open to a large number of malpractices, all of them to the disadvantage of the grower at every step.

Regulated Markets. Various bodies which went into the question of marketing of cotton emphasised the need of establishing regulated markets to check the malpractices rampant in the trade. Accordingly, in Berar (now part of Vidarbha of Bombay State) the cotton markets were regulated under local Municipal laws as early as in 1872. In 1880, a regulated cotton market was established at Karanja under the orders of Hyderabad Residency. Subsequently, a special law known as "Cotton and Grains Market Law" was enacted in Berar in 1897 which provided for the regulation of cotton markets in the districts of Amravati, Yeotmal, Akola and Buldana. Under this law, markets and *bazars* could be notified and committees could be appointed to control them. Rules also could be made to regulate: (*i*) constitution and powers of the managing committee; (*ii*) various market levies; (*iii*) collection and disposal of fees, the conditions of issue of licenses to brokers, weighmen, measures; and (*iv*) place of weighment, and measuring scales, weights and measures to be used, their inspection, verification, correction and so on.

This law was superseded by the C. P. Cotton Market Act of 1932. Three years later, in 1935, another law C.P. Agricultural Produce Market Act was passed to regulate the marketing of all agricultural produce including cotton which was already covered by the earlier act. The new acts were amended in 1953 and named M. P. Cotton Market Act and M. P. Agriculture Produces Act for the Khandesh region. The Government of Bombay, in 1927, passed the Bombay Cotton Markets Act, making suitable provisions for the establishment of regulated cotton markets. Subsequently, in 1939, the Bombay Agricultural Produces Market Act applicable to all agricultural produce was passed and the Cotton Market Act was, therefore, repealed and all cotton market committees under the previous Act were deemed to be the market committees under the new act.

For the Marathwada portion of the Central *arboreum* Region, the Hyderabad State also passed similar laws in 1927.

During the past few decades, regulated markets have been established in other princely States which formed part of the old Madhya Bharat.

At present, the regulated markets established under these various acts function on democratic lines to regulate the buying and selling of cotton. Their working may be briefly summarised as under :

The Government notifies the limits of the 'market area' the 'market proper' and the 'market yard' for the application of the act at different trade centres. Within the prescribed market area, no other market, private or otherwise, is allowed to function. Market proper is usually the municipal limits of the place and the market yard is the enclosed space within the market proper where the cotton is assembled and sold.

Market committees appointed to run the markets have representatives of the growers, the trade, and the local bodies on them, the total strength varying from 12 to 16. The regulated markets are generally self-supporting. The places where regulated markets function in the region are given below.

LIST OF REGULATED MARKETS FOR COTTON IN CENTRAL *Arboreum* REGION

State	District	Market
Madhya Pradesh	Ujjain	Ujjain
		Nagda
		Barnagar
		Khachrod
		Tarana
		Mahdput
	Shajapur	Shajapur
		Shujalpur
		Akodia
		Kalapipal
		Agar
		Nalkheda
		Barchha
		Susner
	Dewas	Dewas
		Sonkatch
		Kannod
		Khategaon
		Hatpipaliya
		Bagli

State	District	Market
Madhya Pradesh (*contd.*)	Ratlam	Ratlam
		Alote
		Jaora
	Mandsaur	Mandsaur
		Neemuch
		Jawad
		Mansa
		Shamgarh
	Vidisha	Shamshabad
	Rajgarh	Sarangpur
		Biaora
		Pachore
		Khelchipur
		Narsingarh
		Jirapur
		Khujner
	West Nimar	Khargaon
		Sanawad
		Barwaha
		Sendhawa
		Bhikangaon
		Anjad
		Khetia
	East Nimar	Burhanpur
	Indore	Indore
		Sawer
	Dhar	Manawar
		Rajgarh
		Kukshi
		Badnawar
		Dhamnod
	Jhabua	Alirajpur
Maharashtra	Akola	Akola
		Akot
		Karanja
		Murtizapur
		Washim
		Telhara
	Amravati	Amravati
		Daryapur

State	District	Market
Maharashtra (*contd.*)	Amravati (*contd.*)	Anjangaon
		Dattapur-Dhamangaon
		Warud
		Chandur Rly.
	Buldana	Malkapur
		Khamgaon
		Shegaon
		Nandura
		Jalgaon
		Chikhli
		Mehkar
		Pimpalner
	Yeotmal	Yeotmal
		Darwha
		Pandharkawada
		Wani
		Pusad
		Ghatanji
		Digras
		Umerhked
		Bon-Bujruk
	Wardha	Wardha
		Pulgaon
		Arvi
		Hinganghat
	Chanda	Chanda
		Warora
	Nagpur	Katol
	Ahmednagar	Shrirampur
		Rahuri
		Sevgaon
		Pathardi
	Jalgaon	Chalisgaon
		Pachora
		Jalgaon
		Amalner
		Chopda
		Bodwad
		Bhusawal

State	District	Market
Maharashtra (*contd.*)	Dhulia	Dhulia
		Dondaicha
		Shirpur
		Shahada
		Nandurbar
		Nawapur
	Nasik	Malegaon
		Nandgaon
		Satana
	Poona	Baramati
	Sholapur	Pandharpur
		Barsi
		Karmala
		Akluj
		Kurdawadi
		Akalkot
	Sangli	Sangli
		Mohol
	Aurangabad	Aurangabad
		Jalna
		Lasur
		Vaijapur
	Bhir	Bhir
		Parli
		Mominabad
		Manjlegaon
	Parbhani	Parbhani
		Hingoli
		Sailu
		Purna
		Parthur
		Basmath
		Manwath
		Gangakhed
	Nanded	Nanded
		Umri
		Karkheli
		Kundalwadi
		Dharmabad
		Deglur
		Mudkhed
		Kinwat

State	District	Market
Maharashtra (*contd.*)	Usmanabad	Latur Udgir Kallam
Andhra Pradesh	Adilabad	Adilabad

CO-OPERATIVE MARKETING

Experience has shown that co-operative marketing proved of immense benefit, both to the consumer and the grower. State Governments in the region, therefore, encouraged the formation of co-operative sales societies for cotton. The position in Khandesh and Vidarbha is as under :

Khandesh. Co-operative cotton sales societies were organised in East Khandesh for the sale of pure Jarila cotton under Agmark. The produce of the members is sold by private treaty. The societies give to the grower 60 to 70 per cent. of the value of cotton, actually deposited in the society's godown at the current market rates. A member is allowed to determine the sale price of his produce.

Vidarbha. Marketing of improved varieties of cotton is undertaken by the Vidarbha Marketing Society under the 'cotton pool scheme'. The *taluka* agricultural organisations affiliated to this apex organisation work as agents for pooling improved varieties of cotton brought by the producers at the selected centers. The marketing society arranges the sale of cotton by auction on commission basis. A commission of Rs. 150 is charged per candy of cotton sold through the society from the growers, of which two-third is returned to the *taluka* association. A spacial Cotton Pool Committee, consisting of the president, secretary and representatives of the growers and the Agricultural and Co-operative Departments transacts business. Experience has shown that the growers of improved varieties of cotton have been able to secure Rs. 15 to Rs. 20 more per candy through the co-operative society.

The *taluka* associations are also agents of the Government for the distribution of pure seed. For the last three years because of the Government of India's policy to issue export licences to co-operative societies, some of these have taken to exporting cotton, through their appointed agents in Bombay and are earning sizable profits.

FORWARD MARKETS

Cotton produced in the region is covered by the Forward Market in Bombay. Prior to 1942, when the East India Cotton Association, Bombay, offered three hedge contracts, one of them—M.P. Oomras—was solely meant for the transaction of the produce of this region. Subsequently, till 1955, there was only one contract with Fine Jarila 3/4″ as the basis. The bulk of the produce of the region centred on it. After 1955, one of the two contracts, Fine Jarila with 25/32″ as the basis, was intended for the region.

In 1956, the Government of India permitted the establishment of markets for forward trading in cotton at Akola and Indore. An association, known as the Central India Cotton Association, has been formed since then and was recognised for conducting forward trading at Indore for three years ending on September 13, 1956. Trading in cotton was started at Ujjain with effect from October 31, 1956.

GINNING

Ginning is the important process whereby lint is separated from seed. It may safely be said that about 95 to 98 per cent. of cotton brought to market is unginned.

Ginning may be done by primitive hand gins or power gins, the former being used very sparingly in the remote interior where holdings are small. It may, however, be said without exaggeration that ginning is exclusively done by power-driven gins, which are all of the roller type, the saw gins being absent in the region. The ginning season in the region lasts for about six months, commencing from October and continuing till April.

Ginning of seed cotton is arranged by buyers who may be merchants, gin-owners or agents of mills. The ginning charges vary locally, ranging from Rs. 10 to Rs. 15 per bale.

PRESSING

Cotton is packed both in loose and compressed bales for trade and transport purposes. Loose packing is adopted for the inland transit of ginned cotton to a pressing factory, while compressed packing is adopted for transporting ginned cotton to the market and for storing in the godown.

Each loose bale, which is called *bora* or *dokra* contains 200 to 300 lb. of lint. As regards the compressed bale, the size and density varies according to the press used. On an average, however, the usual weight of an Indian bale is 392 lb. net (400 lb. gross, including weight of hessian and hoops) with a density of 40 lb.-cu. ft. The bale measures 49 inches (length) x 17 inches (width) x 20 inches (depth). Baling presses are situated either in the premises of the ginnery or in separate factories in the same town.

Ginning and pressing are important items in the marketing of cotton. In India, ginning marks a stage in marketing, at which the cotton grower ceases to take any further interest in tne produce. This position has given rise, in some parts of country, to a class of capitalists, who undertake the ginning and pressing of the growers' cotton. In Khandesh and Vidarbha, the gin-owners do not trade in cotton but gin and press for their customers. So far, there are no co-operative ginning factories in the region. Due to the prevalance of a large number of malpractices, such as watering, mixing, etc., the Government of India, in consultation with the Indian Central Cotton Committee, passed the Cotton Ginning and Pressing Factories Act in 1925, to check the malpractices.

SEED MULTIPLICATION AND DISTRIBUTION

The role of the good sowing seed in cotton agriculture is extremely important, since the quality of lint is an important factor in its marketing. All cultivators try to obtain the pure, healthy seed, of the best adapted variety suited to their soil. This aspect becomes all the more important since the cotton grower has already parted with his own seed after the harvest and the sale of seed cotton.

The sources of sowing seed for the cultivator in the region are:

1. Growers using their own seed obtained by hand-ginning the *kapas* retained for domestic consumption.
2. Landlords who supply seed to the tenants.
3. Ginners.
4. Merchants, who purchase from the ginneries and stock the seed for sale.
5. Department of Agriculture, its approved agents and licensees supplying pure seed of improved varieties.
6. Co-operative societies.

Inquiries made from the Department of Agriculture by the Indian Central Cotton Committee in 1957 showed that in Khandesh 50 per cent. of the sowing seed was obtained from departmental stockists and 50 per cent. from the trade. In Marathwada, 88 per cent. of the seed was obtained from the trade and only 12 per cent. from the Agricultural Department. The position in Nimar and Malwa of Madhya Pradesh was that 30 per cent. of the seed was obtained from the Department and 70 per cent. from ginners and the trade.

SUPPLY OF IMPROVED SEEDS

Production of pure seed in sufficient quantity to cover the entire area of the tract can only be achieved through the establishment of progressively larger stages of seed multiplication, where the crop has to be properly rogued under technical supervision and the produce ginned under vigilant eyes so as to avoid admixture. As such, this work of producing pure seed has to be done by the Department of Agriculture either on its own, under a scheme of the Indian Central Cotton Committee or the Cotton Extension Plan of the Government of India.

The *modus operandi* in seed production in different parts of the region is summarised below :

Khandesh. Under the Scheme for Multiplication and Distribution of Virnar Cotton in the tract, pure seed of this variety is distributed departmentally and through approved agents in bags sealed by the Department of Agriculture. The seed of 'general area' is distributed by the trade; distribution is controlled by the Agricultural Department.

Production of pure seed of Virnar is achieved in four stages : The seed is produced at the Bhadgaon Farm as a first stage. Subsequently it is multiplied on private seed farms. The third or the inner reserve area stage consists in multiplying the seed produced by private farms in compact blocks of an area one-hundredth in size of the total cotton area of the *taluka* in the same village. Lastly, in the outer reserved area stage, the seed produced from the inner reserve area is distributed departmentally on an area eight times the size of the inner reserved area, in compact blocks in the surrounding villages.

The seed obtained from the outer reserve area is handled by trade for covering the entire general area.

The crop is rogued up to the inner reserved area stage only. Stocking and distribution of the pure seed of the outer reserved area is done by growers' associations of each *taluka* which also arrange for the roguing of the crop, ginning, and selling the lint by auction. The seed is then sold to co-operative credit societies, seed merchants and village dealers.

Vidarbha. Nucleus seed of improved varieties of cotton is produced by the Agricultural Department in six stages, the first two of which are on Government Farms. Seed from the third to the sixth stage is grown on the cultivators' fields roguing being done by the growers under the supervision of the departmental staff. After roguing certificates of purity are issued to the growers and they are instructed to join the departmental pools, managed by agricultural associations at each *taluka* centre. These *taluka* agricultural associations arrange for the sale of the pooled *kapas* on a premium system or by auction. The seed is ginned under supervision and purchased by the department and stored with the associations for distribution by the departmental staff.

Marathwada. Seed of improved varieties is multiplied in usual stages, the nucleus and the first generation ones being grown on Government Farms. Three or four more stages constitute the reserve area and are grown in selected villages with approved farmers. The produce of the reserve area is marketed on a premium basis, ginned under departmental supervision and the seed stocked in godowns under departmental control. It is further distributed departmentally on *taccavi* or cash basis.

Other Areas. In Malwa and Nimar region of Madhya Pradesh, the pattern of seed multiplication is the same as in Khandesh and Vidarbha.

In cases where the improved variety to be cultivated belongs to the adjacent stage, like Virnar, its seed is purchased by the department concerned and distributed as a general area.

TABLE 102. IMPROVED SEED DISTRIBUTED AND AREA COVERED BY THEM IN THE CENTRAL *arboreum* REGION

Variety	Quantity of seed distributed in an area									
	1953-54		1954-55		1955-56		1956-57		1957-58	
	Maunds	Area	Maunds	Area	Maunds	Area	.Maunds	Area	Maunds	Area
Vidarbha										
H.420	83,430	10,30,000	84,708	12,04,000	66,340	7,28,061	54,038	5,89,163	13,643	4,02,307
Malini										
Jarila										
Buri 107										
Buri 0394	18,266	1,60,000	18,411	1,91,000	14,462	1,91,970	27,528	2,49,175	18,768	5,45,228
Marathwada										
Goarani 6	—	—	—	—	—	—	69	300	98	503
Goarani 12	48,400	3,00,000	26,867	2,39,107	14,161	2,79,034	3,091	1,90,236	3,009	1,48,069
Daulat	—	—	—	—	981	3,800	1,138	5,700	1,610	8,050
Jarila										
Parbhani										
Malwa										
Malini 9										
Bhoj										
Indore 2										
Maljari (Nimar dist.)	—	—	—	—	—	—	1,647	10,240	8,245	51,505
Jarila										
Buri 0394										
Mathio										
Pratap	692	4,161	1,274	7,731	2,553	8,000	3,310	14,911	7,434	42,111
Khandesh										
Virnar	78,200	6,79,200	54,415	7,54,638	59,484	9,56,993	51,734	8,59,717	50,866	7,77,315
Jarila										

In the Mathio region nucleus seed of Pratap is multiplied at the Amreli Farm and seed multiplication and distribution organised under the scheme of the Indian Central Cotton Committee.

The amount of improved seed distributed in different years in the region is given in Table 102.

After the entire area is covered by the improved seed, the purity of the variety and the crop quality of the area is ensured by enactment of laws prohibiting the growth and import of seed of any other variety.

UTILIZATION OF COTTON AND ITS PRODUCTS

The produce of the cotton plant is *kapas* (seed cotton) which consists of the lint (fibres) and the seed.

LINT

Cotton is cultivated for its valuable fibres—the lint—which is mostly used for the following:

1. Manufacture of cloth by the textile mills.
2. Hand-spinning and for cottage textile.
3. Surgical dressing, etc.
4. Domestic consumption for mattresses, quilts, etc.

The lint produced in the Central *arboreum* Region is consumed mostly by the textile mills located in the region and in the city of Bombay. Table 103 gives the details of the extent of consumption of Oomras and other varieties by textile mills in Indian States.

TABLE 103. MILL CONSUMPTION OF COTTON CROWN IN THE CENTRAL *arboreum* REGION

Variety	1957-58	1956-57	1955-56
	(thousand bales of 392 lb.)		
Mathio	42	44	39
C.P. I and II	10	15	13
C.I. Desi	3	8	17
Oomra Desi	15	12	19
Jarila (including Virnar, Malvi and Verum)	1,230	1,277	1,047
H.420	17	38	60
Hyderabad Gaorani (including 6 and 12)	82	87	96
Buri-American (including Cambodia other than Madras Cambodia)	194	170	94

As regards the quantities used for hand-spinning and cottage industry, the Khadi and Village Industries Commission informs that the total consumption during 1955-56 for its centre at Wardha was 21,945 bales, of which 12,456, 4,774, 3,105 and 2,010 belonged to Jarila, H. 420, 197/3 and Roseum, respectively. It will be seen that *desi* cotton is preferred for hand-spinning because it is comparatively more difficult to manipulate American cotton lint on *charkhas*.

The Government of India has recently allowed the export of certain categories of cotton produced in the region to the following extent:

	1952-53	1953-54	1954-55	1955-56
Oomras	20	30	66	97
Jarila	—	—	4	69

SEED

In addition to sowing, cotton seed is utilised for: (*i*) cattle feed; and (*ii*) cotton seed oil industry.

Cattle Feed. The whole cotton seed is fed to the cattle, instead of the cotton seed cake. This feeding is said to increase the yield of butter fat, and therefore, fed to milch cattle, mostly during the lactation period. For feeding purposes, seed of naked seeded varieties is preferred to the fuzzy ones. Also, *desi* cotton seed is preferred to American varieties which the cattle do not seem to like, probably because of their higher gossypol content.

It is estimated that about 20 to 30 per cent. of cotton seed is used for feeding in the Central *arboreum* Region.

Cotton Seed Oil Industry. Cotton seed is an important source of semi-drying oil which is mostly used in India for edible purposes or soap making. The cotton seed oil is used in the manufacture of Vanaspati. The oil contents of the different cotton varieties grown in the region are given in Table 104.

TABLE 104. OIL CONTENT VALUES OF CERTAIN VARIETIES OF COTTON SEEDS

Variety	Oil content per cent. (on 10 per cent. moisture basis)
Indore 2	17·49
Buri 0394	18·93
Parbhani-American 1	18·15
M.48-4	18·51
Malvi	15·75 to 16·02
Maljari	16·21
Bhoj	17·65
Virnar	19·33 to 20·12
Jarila	18·53 to 18·68
Goarani 12	18·81
Goarani 6	17·20
Local (Marathwada)	17·89 to 18·13
Daulat	16·11
C.J.73	17·51 to 17·53
Pratap	17·17 to 17·33
Mathio	17·99 to 18·84
H.420	14·95

Oil mills are located in the region at various centres, the important ones being at Amravati, Khandwa, etc.

LINTERS

There are a large number of products of cotton seed and oil industry, important one being linters (short fuzz). They are used in the manufacture of surgical cottons, twines, wicks, etc. It may, however, be pointed out that the industries utilising the full potentialities of cotton seed, besides oil, are very much in infancy in this country.

COTTON LEGISLATION

Cotton is the 'white gold' of the black cotton soil since it brings money to the region. As such, unscrupulous interests always try to adopt ingenious and ever new malpractices and frauds at every step at the cost of the growers, the consumers and the national economy. The Government had to step in to promulgate various laws from time to time to check the various evils and also promote the well-being of cotton cultivation of the country. These laws as they operate in the Central *arboreum* Region are briefly described below:

COTTON TRANSPORT ACT (1923) (CENTRAL LEGISLATURE)

The Government of India, in 1923, passed this Act with a view to maintaining the quality and reputation of the cotton grown in any area (called the protected area) by prohibiting the import, by rail or road or sea, of lint, *kapas*, cotton seed, or cotton waste into specified areas unless required for a special purpose and covered by a licence granted by competent authorities.

Provisions of the Act are made applicable to particular tracts by constituting them into protected areas. So far as the Central *arboreum* Region is concerned, under this Act, the following protected areas have been declared by the relevant authorities:

Khandesh Cotton Tract. Comprising East and West Khandesh and Nasik districts.

Vidarbha and Madhya Pradesh Area. Buldana, Akola, Amravati, Yeotmal, Wardha, Nagpur, Bhandara and Chanda districts of Vidarbha, and Chhindwara, Betul, Khandwa, and Hoshangabad districts of Madhya Pradesh.

Gaorani Protected Area. Comprising the districts of Nanded, Osmanabad and parts of Parbhani and Bhir districts of Marathwada, declared protected area under the Hyderabad Cotton Cultivation and Transport Act, since the area then comprised the old princely State of Hyderabad which could not be covered by the Cotton Transport Act, 1923.

COTTON CONTROL ACT (STATES ACTS)

With a view to further strengthening the rules and provisions of the Cotton Transport Act, the various State Governments passed legislation to empower the Government to fix standard varieties for cultivation in particular areas and to prohibit the growing, possession or trade in other varieties in the specified areas. It also prohibited the mixing of prohibited varieties. It, however, permitted mixing in spinning mills provided the cotton so mixed is not pressed into bales and is used for the manufacture of yarns in the mills.

So far as the region is concerned, the old State of Bombay passed the Cotton Control Act, 1942, and applied it to the Khandesh tract (East and West Khandesh and Nasik) for growing Virnar cotton.

The former State of Madhya Pradesh, which controlled the present Vidarbha region of Bombay State, declared that Pusla and Jarund revenue circles of the Amravati district and the Wani-Welabai, and Sakra-Moregaon circles of Maharashtra State to cultivate only H.420 and Buri 0394.

COTTON GINNING AND PRESSING FACTORIES ACT, 1925 (CENTRAL)

This is another statutory measure enacted with a view to checking the malpractices prevalent during the course of ginning and pressing of cotton. The Act provides for: (*i*) compulsory licencing of all ginning and pressing factories; (*ii*) allocation of mark to each of them to be stamped on bales pressed by them; (*iii*) regulation of the management and structural needs; and (*iv*) obligation to supply weekly returns of cotton ginned and pressed.

It also empowered State Governments to make such rules as are in conformity with the Act.

The State Governments of the region have not only enforced the main provisions of this Act but also have amended them to prohibit watering and mixing of cottons.

Besides the above, following other Acts are in force:

COTTON STATISTICS ACT

Legislation has been enacted in different States covering the region with a view to compiling statistics of cotton stocks held by the trade at the end of the season.

AGRICULTURAL PRODUCE MARKETS ACT

As already mentioned, legislation has been enacted to establish regulated markets of cotton.

INDIAN COTTON CESS ACT

This Act provides for the creation of a fund for the improvement and development of the growing, marketing and manufacture of cotton in India. For this purpose, a cess at the rate of four annas per standard bale of 400 lb. or in the case of unabled cotton at one annas per 100 lb. is levied on all cotton exported or consumed in any mill in India.

ACKNOWLEDGEMENT

In preparation of the above article, all publications of the Indian Central Cotton Committee, Bombay, including all the numbers of 'The Indian Cotton Growing Review' were freely consulted. It is difficult to enumerate all of them.

I am also grateful to the staff of the Cotton Research Scheme, Amravati, for helping me in various ways in completing this chapter.

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I.C.C.C. = Indian Central Cotton Committee.

I.C.G.R. = Indian Cotton Growing Review.

CHAPTER III

SOUTHERN *HIRSUTUM-ARBOREUM* REGION

INTRODUCTION

The Sourthern *hirsutum-arboreum* Region comprises the re-organised States of Madras and Kerala. The two States together cover a total area of 64,772 square miles (Madras 50,171 square miles; Kerala 14,601 square miles) and are situated between 80° S. and 14° N. longitudes and 75° W. and 80° E. latitudes. The territories forming the two States as constituted under the States Re-organisation Act of 1956 are specified below :

Re-organised State	Territories included
Madras	— Madras State, plus Agastheswaram, Thovala, Kalkulam and Vilavancode *talukas* of Trivandrum district and Shencotah *taluka* of Quilon district of Travancore-Cochin State.
Kerala	— Travancore-Cochin State, excluding Agastheswaram, Thovala, Kalkulam and Vilavancode *talukas* of Trivandrum district and Shencotah *taluka* of Quilon district, plus Malabar district (excluding the islands of Lacadive and Minicoy) of Madras State.

Cotton occupies an important place in the agricultural and industrial economy of Madras State, while it is only a minor crop in Kerala State.

AREA AND PRODUCTION

The average annual area and production of cotton for Madras State for the quinquennium ending 1955-56 were 8,18,000 acres and 2,55,000 bales of lint, while the corresponding figures for Kerala were 17,800 acres and 7,400 bales, respectively. The region as a whole accounts for about five per cent. of the total area under cotton in India and contributes roughly 6.7 per cent. of the country's total production. A major portion of the crop in Madras State and the entire crop in Kerala is grown under rainfed conditions. The annual area of irrigated cotton in Madras during the five years ending 1953-54 ranged between 1,21,000 and 1,85,000 acres.

The state-wise area and production are depicted in Figures 19 and 20.

Tables 105 and 106 show the annual area and production of each variety for the period from 1937-38 to 1955-56. A downward trend in planted area and production, which was noticed in 1942-43, continued up to 1947-48. Although the production increased subsequently to about 3,00,000 bales,

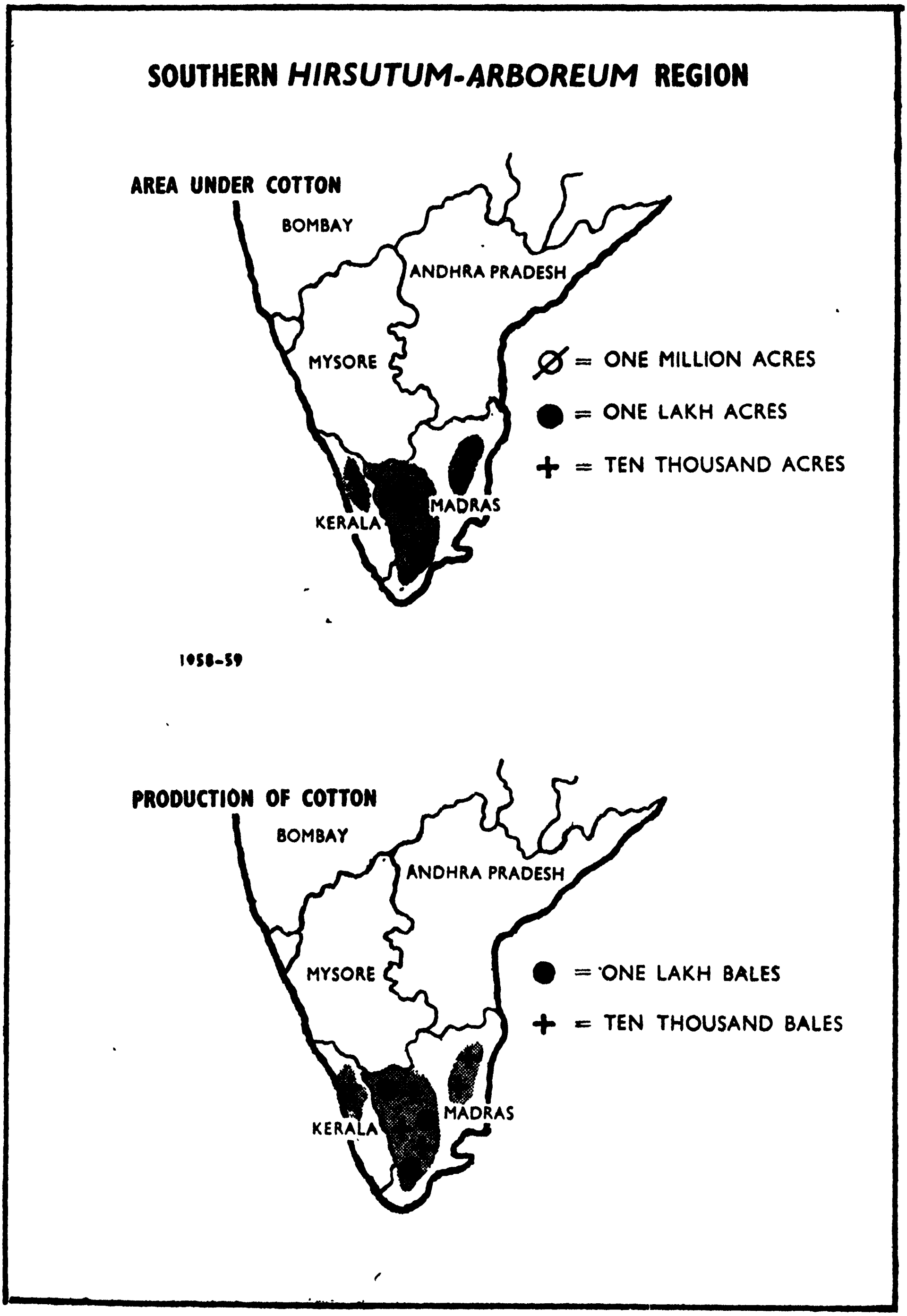


Fig. 19. Intensity of Area and Production of Cotton in the Southern *hirsutum-arboreum* Region—1958-59

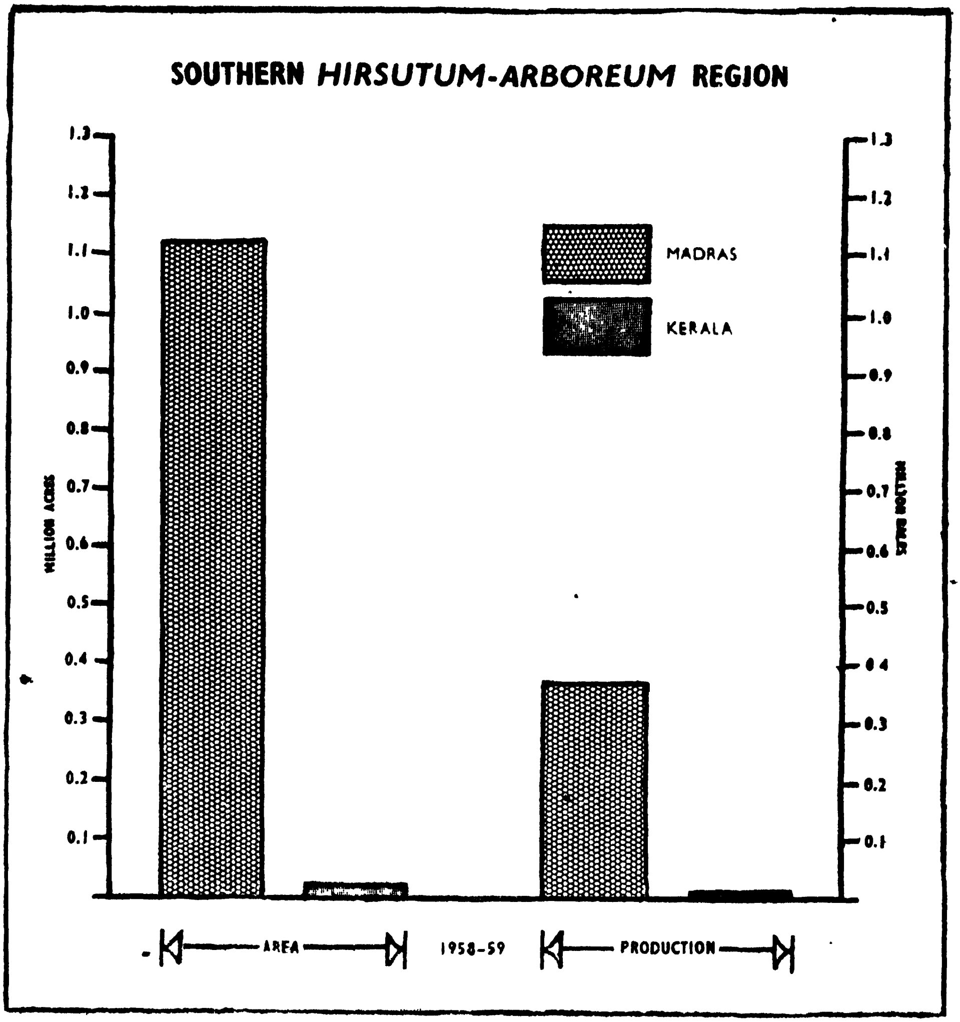


Fig. 20. State-wise Area and Production of Cotton in the Southern *hirsutum-arboreum* Region—1958-59

the level never reached the production of 1941-42. The main contributory causes for this decline were: (*i*) imposition of Government control on cotton prices; (*ii*) cultivators' preference for other cash crops (like groundnut), which were left outside the price control; (*iii*) diversion of areas to food crops which received certain special concessions under the Grow-More-Food Campaign; and (*iv*) various legislative restrictions imposed on the cultivation of cotton. The present production is less than half of the 7,00,000 bales annually required by the textile mills in the region. If the planned expansion of the textile industry during the next decade is also taken into account, the cotton production of this region has to be stepped up to 10,00,000 bales. Efforts in this direction are already under way.

TABLE 105. ANNUAL AREA UNDER COTTON—MADRAS STATE

Year	Variety-wise area (acres)				
	Cambodia	Tinnevellies including Karunganni	Uppam	Nadam and Bourbon	Total
1937-38	5,64,257	6,21,996	1,91,644	4,289	13,82,186
1938-39	3,19,832	5,51,425	11,116	37,109	9,19,481
1939-40	3,66,125	7,17,835	27,314	24,661	11,35,935
1940-41	5,17,986	7,09,841	20,443	33,424	12,81,694
1941-42	6,36,150	7,23,709	22,133	31,726	14,13,718
1942-43	5,61,944	6,24,353	23,106	7,823	12,17,226
1943-44	5,27,312	6,21,976	19,727	16,159	11,85,174
1944-45	3,15,882	5,52,267	13,989	1,215	8,83,353
1945-46	3,77,338	5,51,295	11,543	1,276	9,41,452
1946-47	3,86,769	4,63,266	11,479	709	8,62,223
1947-48	2,02,178	4,17,120	8,910	2,911	6,31,119
1948-49	2,13,093	5,34,003	10,486	849	7,58,431
1949-50	3,01,603	3,94,774	11,441	275	7,08,093
1950-51	2,36,425	4,97,115	10,394	1,238	7,45,172
1951-52	3,21,408	5,48,742	9,061	1,850	8,81,061
1952-53	2,37,044	4,87,278	3,164	—	7,27,486
1953-54	3,31,148	4,64,237	63,187	472	8,59,044
1954-55	3,38,300	4,68,800	64,100	500	8,71,700
1955-56	4,16,300	4,29,036	1,33,164		9,78,500
Average	3,77,426	5,42,109	21,958	9,249	9,09,687

TABLE 106. ANNUAL PRODUCTION OF COTTON—MADRAS STATE

Year	Variety-wise production of cotton lint (bales of 392 lb.)				
	Cambodia	Tinnevellies including Karunganni	Uppam	Nadam and Bourbon	Total
1937-38	2,13,620	1,51,100	36,460	230	4,01,410
1938-39	1,69,560	1,77,210	1,260	1,470	3,51,500
1939-40	1,42,890	1,58,050	2,800	1,250	3,04,990
1940-41	2,19,530	1,62,690	3,110	1,600	3,86,930
1941-42	2,56,240	1,69,920	3,370	1,540	4,31,070
1942-43	2,49,930	1,41,600	3,290	360	3,95,180
1943-44	2,38,600	1,28,940	2,900	770	3,71,210
1944-45	1,49,710	1,31,450	2,110	60	2,83,330
1945-46	1,73,100	1,21,870	1,690	60	2,96,720
1946-47	1,65,950	89,910	1,520	30	2,57,410
1947-48	94,980	85,470	1,165	119	1,81,734
1948-49	1,13,482	1,26,637	1,642	38	2,42,799
1949-50	1,91,420	1,08,440	2,190	20	3,02,070
1950-51	1,12,890	1,12,850	1,480	60	2,27,280
1951-52	1,57,810	1,38,800	1,470	100	2,98,180
1952-53	98,480	1,14,290	450	—	2,13,220
1953-54	1,50,200	1,01,550	12,800	20	2,64,570
1954-55	1,51,500	1,08,600	10,400	—	2,70,500
1955-56	1,96,400	1,06,000	16,200		3,18,600
Average	1,70,862	1,28,167	3,894	408	3,10,405

The area and production of cotton during the First and Second Five-Year Plan periods is depicted in Figure 21.

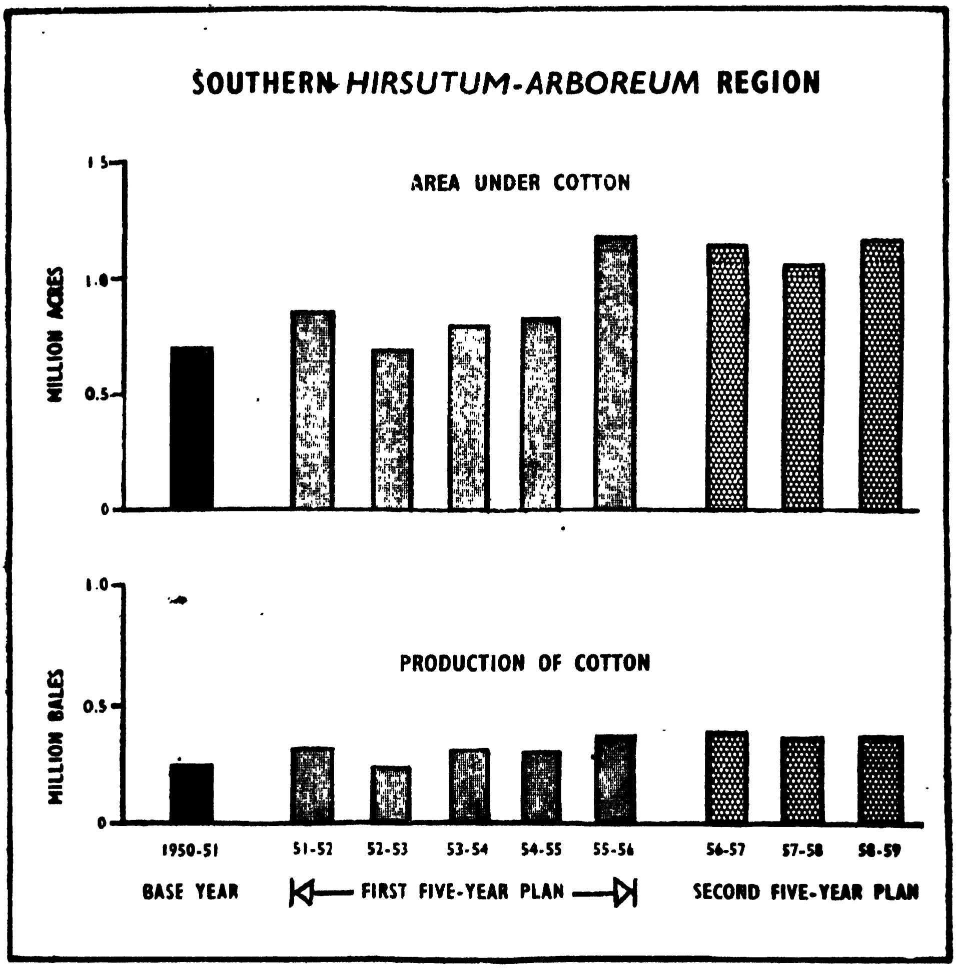


Fig. 21. Area and Production of Cotton in the Southern *hirsutum-arboreum* Region During the First and Second Five-Year Plan Periods

COMMERCIAL VARIETIES

The commercial crop of the region is made up of indigenous and exotic varieties grouped botanically under the genus *Gossypium*. The Cambodia cotton belonging to the species *G. hirsutum* race *latifolium* is the long and superior medium stapled variety, known to the trade as Madras-American. The *desi* (indigenous) cottons fall under the species *G. arboreum* race *indicum* and *G. herbaceum* race *wightianum* and constitute the medium and short staple growths. They are classified as Karunganni, Tinnevellies, Salems and Nadam in

TABLE 107. PARTICULARS OF COMMERCIAL VARIETIES OF COTTON

Variety	Botanical species	District of growth	Area (acres)	Production (bales of 392 lb. lint)	Staple length (inch)	Mill spinning capacity (Warp counts)
Madras-American Cambodia (including Madras Uganda cottons)	*G. hirsutum* race *latifolium*	Coimbatore, Salem, Tiruchirapalli, Madurai, Ramanathapuram, and Tirunelveli	2,16,498 1,35,929 63,873	1,46,867 47,217 2,316	1″-1-3/32″ 15/16″ 7/8″	36's-38's 24's-28's 22's-26's
(Tinnevellies) Karunganni ordinary	*G. arboreum* race *indicum*	Coimbatore, Tiruchirapalli, Madurai, Ramanathapuram and Tirunelveli	84,500	13,999	13/16″-14/16″	16's-20's
Salems, Uppam and	*G. arboreum* race *indicum* grown mixed with varying proportions of *G. herbaceum* race *wightianum*	Coimbatore, Salem and Tiruchirapalli	1,33,164	16,200	11/16″-13/16″	14's-18's
Nadam and Bourbon	*G. arboreum* race *indicum* mixed with *G. hirsutum* race *punctatum*					

trade. Since the short staple Salems and Nadam are being fast replaced by medium staple varieties, the region will eventually become a producer of long and medium staple cottons only. Particulars relating to the commercial varieties under cultivation are given in Table 107.

SOILS AND CLIMATE

SOILS

The principal soil types on which cotton is grown in this region are the following:

Variety	Soil types
Madras-American (Cambodia)	— Red loam to light black with a large percentage of coarse fractions.
Karunganni, Tinnevellies and Salems	— Light black to heavy black with high clay content.
Nadam and Bourbon	— Shallow, red, poor soils, intermixed with fine gravel.

It may be observed that : (*i*) the soils are predominantly red; (*ii*) the sandy types are largely confined to the coastal belts in the east and west; (*iii*) black soils are common in Tirunelveli, Madurai, Ramanathapuram, and in parts of Coimbatore, Salem, Tiruchirapalli and South Arcot districts; (*iv*) alluvial type occurs in Tanjore and in patches in Ramanathapuram, Madurai, Tiruchirapalli, Coimbatore and Chingleput districts; (*v*) saline areas exist in the coastal regions; and (*vi*) alkaline belts are found as isolated patches in the inland districts.

The soils are generally deficient in humus and nitrogen. Phosphoric acid is insufficient in intensely cropped areas. Adequate quantity of potash is present except in coastal soils of lateritic origin. Crop response to applications of nitrogenous manure is very high. The traditional practice of ploughing in plant stubble, green leaf, compost and cattle manure helps the maintenance of soil fertility. Soil erosion is a serious problem on hill slopes and in the plains, where the rainfall is received in sharp showers of short duration and where the soil is unable to absorb the rain water quickly.

The central and eastern districts of Madras form a flat plain, with occasional undulating areas in Salem and North Arcot. On the other hand, Nilgiris and the greater part of Kerala State are characterised by hill ranges alternating with fertile valleys.

RAINFALL

The rainfall is highly variable (Table 108) and, therefore, the pattern of agricultural operations and the crops grown in the region depend on the incidence and distribution of rains. Nilgiris district and most of Kerala State depend upon south-west monsoon and receive 60 to 100 inches of rain. The

TABLE 108. NORMAL RAINFALL IN MADRAS AND KERALA STATES (inches)

Place	South-west monsoon			North-east monsoon			Winter			Hot weather			Total
	June	July	August	September	October	November	December	January	February	March	April	May	
MADRAS STATE													
Chingleput	2·0	3·5	5·0	5·2	10·2	12·1	4·6	1·3	0·5	0·4	0·6	1·4	46·8
South Arcot	1·8	2·9	5·4	5·7	8·9	10·9	5·4	1·7	0·6	0·5	1·1	1·9	46·8
North Arcot	2·4	3·4	5·3	6·5	6·5	6·4	2·3	0·9	0·3	0·4	1·9	2·6	37·9
Salem	2·2	2·5	4·3	5·3	6·1	4·0	1·2	0·4	0·3	0·5	1·7	4·1	32·6
Coimbatore	1·4	1·5	2·1	2·9	6·6	4·4	1·4	0·5	0·4	0·7	2·1	3·4	27·4
Tiruchirapalli	1·4	1·6	3·7	4·9	7·1	5·9	2·7	1·0	0·4	0·5	1·7	3·3	34·2
Tanjore	1·4	1·9	3·8	4·2	8·2	11·6	6·9	2·2	0·7	0·7	1·5	2·0	45·1
Madurai	1·3	1·4	2·7	3·5	7·3	6·1	2·3	1·0	0·6	0·8	2·4	2·9	32·3
Ramanathapuram	0·9	1·2	2·4	2·8	7·1	7·1	3·5	1·5	0·8	0·9	2·1	2·0	32·3
Tirunelveli	0·8	0·7	0·8	1·1	6·7	7·9	4·4	1·8	1·2	1·5	2·1	1·4	30·4
Nilgiris	9·4	14·5	10·6	7·1	10·0	6·9	2·6	1·3	1·0	1·4	3·6	6·0	74·4
KERALA STATE													
Malabar	30·40	33·90	18·60	8·30	10·60	5·40	1·00	0·30	0·30	0·80	3·40	8·10	121·10
Kottayam	26·83	24·74	15·24	10·31	13·33	8·61	2·20	1·02	0·86	2·03	5·34	9·14	109·65
Quilon	21·63	16·77	9·87	7·92	13·16	8·94	2·22	1·36	1·00	2·26	5·23	8·87	99·23
Trivandrum	11·63	5·07	2·75	4·62	10·68	8·89	2·44	1·52	0·53	1·98	3·80	5·29	59·20
Trichur	27·98	25·92	14·18	8·43	11·88	6·37	0·98	0·38	0·39	0·99	2·89	9·08	109·47

districts of Chingleput, South Arcot, Tanjore, Madurai, Ramanathapuram and Tirunelveli, situated near the East Coast, receive about 50 inches of rain during the north-east monsoon, the quantity decreasing gradually from the coast inwards. The inland districts of North Arcot, Salem, Coimbatore and Tiruchirapalli benefit to a limited extent from both the monsoons, receiving about 30 inches of rain in the whole year. The distribution of rainfall in the States is shown in Figure 22.

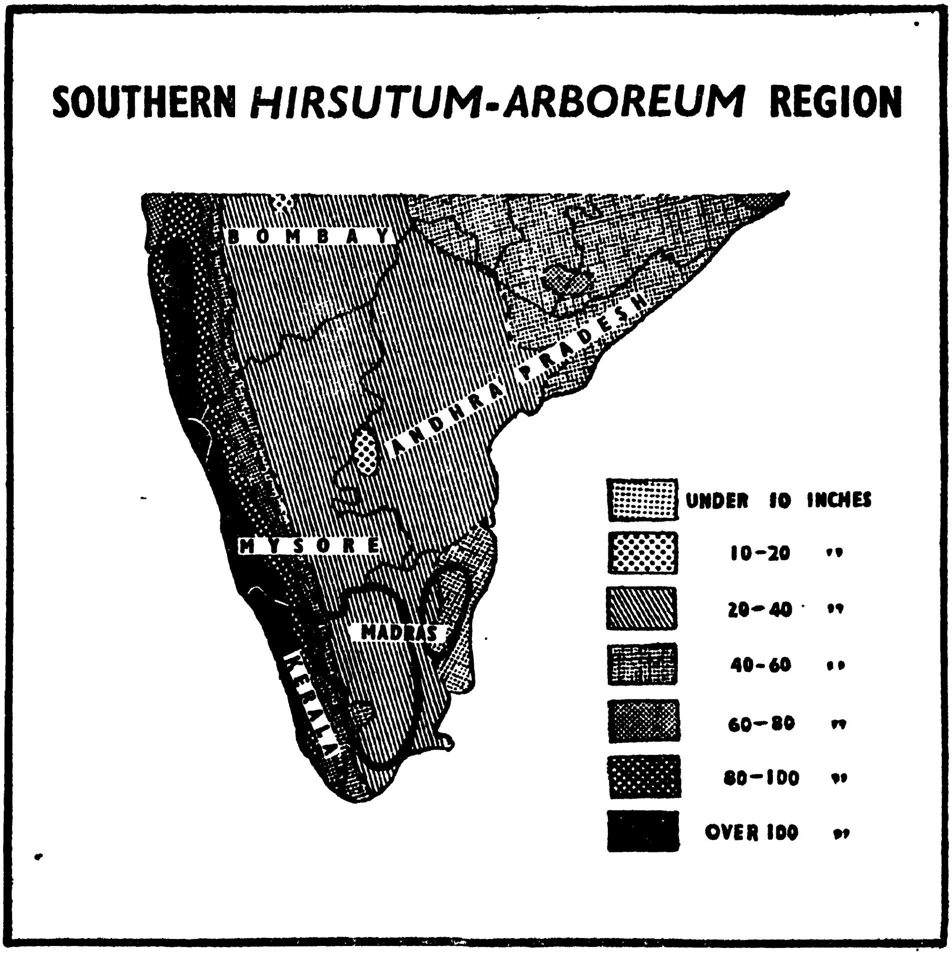


Fig. 22. Rainfall Pattern of the Southern *hirsutum-arboreum* Region

TEMPERATURE

The mean annual temperature is about 85°F. on the East Coast and between 80° to 82.5°F. in parts of North Arcot, Salem, Coimbatore and Madurai districts. It is lower still in places situated on hill slopes and in the valleys of the West Coast and in the mountainous parts of the Nilgiris, Coimbatore and Salem districts.

The climatic complex is generally suitable for the cultivation of American and *desi* varieties in all districts except the mountainous Nilgiris and the high rainfall tracts in the West Coast. Cotton grown in the Southern Region falls into seven ecological groups, viz., Winter Cambodia, Summer Cambodia, Karunganni, Tinnevellies, Uppam, Nadam and Sea Island. Only the Cambodia cotton varieties are grown both as irrigated and rainfed crop, all others being cultivated under rainfed conditions.

COTTON CULTIVATION

The cultivation of Cambodia is restricted to red and reddish loams in areas receiving an annual rainfall of about 30 inches or possessing facilities for supplemental irrigation from wells or canals. Karunganni, Tinnevellies and Uppam are grown on the black soils in tracts having a rainfall of nearly 30 inches in a year, the last two of them being confined to areas where the rainfall is undependable and fluctuating. The Nadam variety is confined to poor, gravel-bearing and unretentive soils. In such an environment, the Nadam crop is kept on the ground for three consecutive years. Although Sea Island cotton has a negligible area under cultivation for the present, it possesses great potentialities for extension to the coastal tracts, from Kanya-Kumari to Mangalore, which receive good rainfall during the south-west monsoon. The hot and humid climate together with the well-drained open soils, characteristic of this tract, are well suited to the cultivation of this variety.

Well water in areas growing irrigated Cambodia is slightly blackish. The farmers believe that cotton thrives well on such water. In the canal-irrigated Lower Bhavani Project, good quality water is available but the soils are shallow, open in texture and infertile. Their fertility status has to be improved considerably before good crops of cotton can be grown on them.

IMPROVED VARIETIES

INTRODUCTION OF EXOTIC TYPES

In order to explore the possibilities of large-scale cultivation of long staple cotton suitable for British textile mills, experiments with imported *barbadense* and *hirsutum* varieties were initiated at several places in Madras in the first half of the 19th century by the East India Company. The earliest record of such trials dates back to 1790 A.D. when Dr. Anderson distributed seeds imported from Mauritius. Other exotic varieties were tried by the East India Company in two other periods, i.e., 1800 to 1819 and 1845 to 1853. Although hopes of successful acclimatisation were periodically expressed during the pendency of these trials, the venture proved a failure. The only surviving relic of these experiments is the Bourbon cotton now found mixed with indigenous Nadam as a perennial crop in some parts of Coimbatore and Salem districts. Although the interest in such large-scale cultivation waned by about 1860, the study of many of the American types was continued at the Agricultural Farms of the State until the end of the 19th century. Sea Island, Brazilian, New Orleans and Upland-American varieties were tried in the College Farm at Saidapet during 1878-1890 but all of them succumbed to an attack of jassids (*Empoasca* spp.). Peruvian, Egyptian, Caravonica, Sea Island and American cottons were tried again during 1905 in farms at Attur, Taliparamba and Koilpatti, but the results were no better.

In 1906, some *kapas* (unginned cotton) of an American variety was found as mixture in bales of lint imported in Pondicherry from Indo-China. Mr. Benson, of the Madras Agricultural Department, obtained some seed of this cotton from the President of the Chamber of Commerce, Pondicherry, and tried it on the black soils of Tirunelveli district as an unirrigated crop. It proved a thorough failure, but in the succeeding year, Mr. Steele, of Harvey and Company, discovered its great potentialities when grown under irrigation at Virudunagar. The good performance encouraged the *ryots* in Virudunagar and the neighbouring districts to take to its cultivation with eagerness. Its subsequent expansion was spontaneous and phenomenal. The farmers extended its cultivation also to the unirrigated red soil tracts receiving an annual rainfall of about 30 inches. The total area under the variety rose to 3,05,000 acres in 1920. In trade, the variety came to be known as Cambodia, which was the name of the place in Indo-China from where the seeds had originated. On receipt of complaints about the deterioration of cotton varieties, the Government appointed a whole-time Cotton Specialist in 1920 for the improvement of Cambodia and other indigenous cottons. The crop improvement work was initiated at the Cotton Breeding Station, Coimbatore, and other agricultural farms located in the respective cotton zones.

The initial trials for the acclimatisation of *barbadense* varieties also present a picture of total failure. Sea Island seed imported from Georgia was tried in 1831 as a rainfed crop in the districts of South Arcot, Salem and Coimbatore. Subsequently, experiments were carried out by the Agricultural Department at Attur and Saidapet Farms. All the trials proved unsuccessful. Interest was once again revived when Sea Island and Egyptian cottons were tried by the Agricultural Department in 1930 in farms in Malabar district. The yields in all the experiments were very low as the crop suffered badly from pink bollworm. At about the same time, a private farmer in South Kanara obtained seeds of Montsérrat and St. Vincent varieties and conducted trials in his own land. This cultivation did not extend beyond his own homestead, and the residential compounds of a few of his intimate friends. However, these trials showed that plant growth, crop yield, opening of bolls, and the quality of produce were satisfactory and that the variety could stand shade and be made to grow as a perennial for seven years by judicious pruning.

Encouraged by this experience, exploratory trials with Sea Island cotton were started once again in 1949 in Government Farms on the West Coast under a scheme financed by the Indian Central Cotton Committee. Trials were conducted with the two above-mentioned varieties to determine : (*i*) their performance as a rotation crop on light *modan* soils found on hill slopes and as an inter-crop in the coconut plantations and on *kumeri* lands; and (*ii*) their optimum agronomic requirements. Later work included varietal trials too. The work done so far has shown that the variety 'Andrews' behaves exceedingly well under proper cultivation. Crops raised from seed, treated with organo-mercurial formulations against blackarm and planted early in June on land manured adequately with farm yard manure, ash and ammonium sulphate, weeded and hoed regularly, sprayed with pesticides like Folidol and Endrine and fungicides like Cupravit or Perenox have given yields of about 800 lb. per acre. This variety has a staple length of 1.25 inches, a ginning outturn of 33 per cent. and a spinning capacity of about 80's standard warp counts. The Indian Central Cotton Committee has recently sanctioned a comprehensive scheme for the extension of cultivation of this variety in Kerala, Mysore and Assam States.

VARIETAL IMPROVEMENT WORK

The cotton crop of the zone has, in the past, suffered from three main defects, viz., low acre yields, poor quality of fibre and high cost of production. Some of the other drawbacks were the fluctuating performance of the varieties and the cultivation of a multiplicity of strains even in a small tract. The basic policy in cotton breeding work has always been the improvement of quality by conversion of all : (*i*) short and medium-short staple *desi* cottons into medium-long staple groups of 7/8" staple ; and (*ii*) exotic cottons into long staple varieties with a staple length exceeding one inch. Concurrent with this work, other experiments were undertaken to increase production per acre by improving ginning outturn, and reducing crop loss caused by pests, diseases and environmental hazards. The progress of the work is narrated briefly in the following paragraphs. The staple-wise production during 1958-59 is shown in Figure 23.

Gossypium hirsutum race **latifolium.** Pure line work for the improvement of Cambodia cotton started in 1920 at Coimbatore. The first fruits of selection were two strains, viz., Combodia 1 and Cambodia 2. The latter proved to be hardy, vigorous, productive, longer stapled and suitable for cultivation on red soils under irrigation and as rainfed crop in areas receiving about 30 inches of rainfall. Its release in 1929 proved popular with the farmers and helped the extension of its cultivation to new areas.

In 1932, the work on *hirsutum* cotton was directed towards the production of still better varieties, and Cambodia 2 was crossed with several improved varieties obtained from America, Africa and Russia. Crosses with Uganda

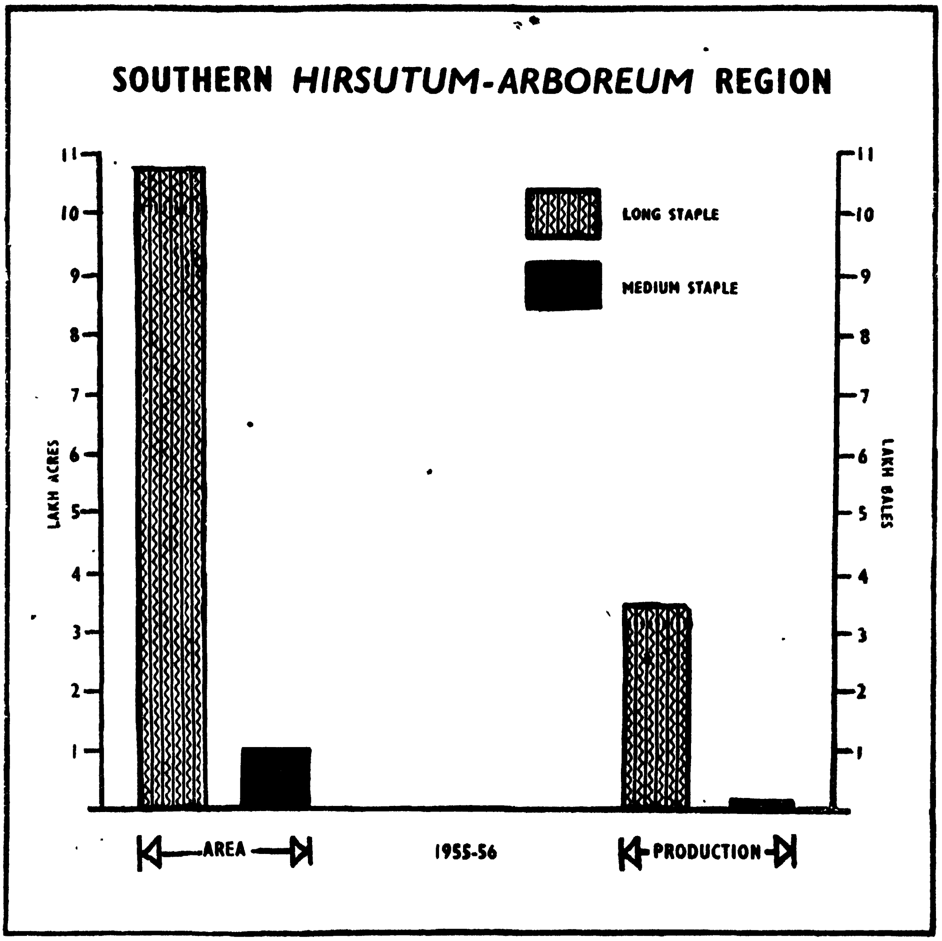


Fig. 23. Area and Production of Cotton According to Different Staple Lengths in the Southern *hirsutum-arboreum* Region

varieties yielded three new types, namely, 4463, Cambodia 3 and Cambodia 4. These strains were not only early maturing, but had also longer and finer fibres. The variety 4463 was taken up by garden land farmers of Coimbatore *taluka*, while Cambodia 3 found favour as irrigated as well as rainfed crop in Salem district which usually suffers from water scarcity and has relatively infertile and open soils. The early maturing and superior staple Cambodia 4 variety attained pre-eminence in Ramanathapuram and Madurai districts which grow a fairly large area of irrigated, summer crop.

Though good in many respects practically all the new varieties were suitable for only limited areas and suffered from blackarm (bacterial blight). The varietal improvement work was, therefore, re-orientated in 1943 to the production of a more cosmopolitan and disease-resistant type. Reselection in Cambodia 4 produced Madras Cambodia Uganda 1 (M.C.U.1) which is early maturing, long stapled, tolerant to blackarm and highly cosmopolitan in adaptability to different seasons and modes of cultivation. This is now replacing the other varieties over a large area of irrigated cotton. Similarly, continued reselection in the interspecific (*hirsutum* × *barbadense*) hybrid 7682 produced another strain, Madras Cambodia Uganda 2 (M.C.U.2). This is longer stapled, better spinning and earlier maturing than M.C.U.1 and it has quickly replaced all varieties growing in the summer planted area. It is probably the first record of successful transfer of long lint genes from *G. barbadense* to *G. hirsutum*.

From the tract growing irrigated Cambodia cotton in the winter season, another variety 9030G (Plate IX), having a staple length of full one inch, has been evolved from inter-*hirsutum* crosses in which the Brazilian Moco cotton was one of the parents. This variety has proved better than M.C.U.1 in the irrigated winter cotton area. Further trials conducted with it since 1950 at Periyakulam, the heart of rain-grown Cambodia, has shown that 9030G is equally well suited for cultivation under unirrigated conditions. The rainfed American cotton in Madras occupies as much area as irrigated winter cotton under wells but due to the vagaries of weather, gives highly fluctuating, low lint yield of poor maturity and of varying staple length. The variety 9030G seems capable of yielding a fair quality crop even under rigorous climate.

Exploratory work on the possibility of growing cotton as second crop on single crop rice lands of Cauvery delta and tank-fed wet lands of neighbouring districts was started in 1934 at the Government Farm, Aduthurai but it failed to yield any practical results. The investigation was revived once again in 1948 with short duration varieties. The trial showed that the Punjab-American variety 216F planted in January-February and irrigated a few times could produce about 1,000 lb. of *kapas* per acre before the end of June, i.e., before the succeeding paddy crop became due for planting. The installation of filter-point tube-wells for supply of irrigation water, and the distribution of pure seed of this variety has encouraged the cultivation of high quality cotton in an erstwhile 'no-cotton' tract.

Wild Cottons. In addition to hybridisation between cultivated races, crop improvement work involving the employment of wild cottons in both American and Asiatic groups has been in progress since 1935 and further intensified from 1945. Special methods like induction of polyploidy through the use of alkaloids were adopted. Fertile tetraploids were isolated from *G. hirsutum* race *punctatum* (*taitense*) × *G. barbadense* race *darwinii* × *G. hirsutum* race *latifolium* and from (*G. hirsutum* race *latifolium* × *G. raimondii*) doubled and crossed with *G. hirsutum* race *latifolium* and *G. barbadense* varieties. Strains with a staple length of 1-1/8″ and low fibre weight, coupled with fibre maturity exceeding 81 per cent. have been obtained. These types also possess good plant vigour, drought resistance, and high flower fertility. The promising selections, which are early maturing and resistant to diseases and pests are now under field tests in the winter crop areas.

In *desi* groups, *G. arboreum* race *indicum* was crossed with *G. anomalum* for the purpose of transferring genes for low fibre weight and bollworm resistance. The work falls under a long range programme and a number of desirable selections is undergoing progeny row trials.

Perennial Cottons. In order to supply the requirements of hand-spinning, which is actively assisted under the *Khadi* Development Scheme, trials of perennial varieties were undertaken on Government Farms all over Madras State. The Brazilian variety, Moco (*G. hirsutum* race *marie galante*) has been found to do well in backyards and to stand pruning for three years. The seeds of this variety have been distributed for homestead cultivation.

Desi Cottons. In the Karunganni area, the trade varieties Karunganni, Tinnies and Salems are in common cultivation. The last two varieties are mixtures of two distinct botanical types, *arboreum* (Karunganni) and *herbaceum* (Uppam). It is commonly believed that in years of good rainfall, Karunganni does well while in years of scanty rains, Uppam fares better. On account of this belief, the farmers prefer to grow a mixture of the two as an insurance against total crop failure due to the vagaries of the seasons. All official propaganda discouraging the practice, and cautioning the cultivators about the attendant ill effects of such mixtures on the quality and price of Karunganni cotton proved fruitless. Work was, therefore, started in 1923 for the production of an improved variety having the hardiness of Uppam and the fibre qualities of Karunganni. The variability in Uppam was low and hence there was no response to selection. The drought resistance attributed to Uppam was not confirmed in field studies and the hybrid vigour of Uppam *vs.* Karunganni crosses had probably been mistaken for the drought resistance of Uppam. Karunganni selections suffered heavy bud and boll shedding during untimely rains in January-February. Extra provincial hybrids too were found misfits for the tract. However, notable success was achieved in the hybridisation within *arboreums.* Two cross-bred selections, viz., K.2 and K. 5 (Plate X), gave high yields under varying soil and seasonal conditions and possessed a staple length of full 7/8″ and were adjudged capable of spinning 30's counts. The former found favour in the Tinnies tract, while the latter spread in the Salems area where pockets of black soil exist intermixed with red soils growing Cambodia cotton. Together, they replaced Karunganni and other earlier varieties like Company 2, Company 3, A.10 and C.7, which were then in cultivation in pure or mixed form. Another new strain 6186-9, superior to both K.2 and K.5 in yield, quality of lint and adaptability, is being multiplied for supply of seed to the cultivators.

The new hybrids derived from *arboreums* were subjected to intensive reselection and further crossing. Transgressive variants equalling 1-1/16″

staple were obtained. Their spinning capacity touched 40's warp counts but no large improvement in yield, ginning outturn or adaptability was noticed. Such long staple strains are now under field trials.

Efforts to replace Nadam, which is susceptible to perennial pests, by an annual type have failed. The hazards of weather and insect attack have militated against the successful introduction of hardy annuals in its place. All annual forms sown in September-October recorded sub-normal yields due to erratic distribution of rainfall and the very light nature of soil in the Nadam tract. In some years, it was not possible even to sow the crop at proper time. As most of the Nadam zone will receive the benefit of the Lower Bhavani Irrigation Project either directly or by an increase in the underground water supply resulting from canal irrigation, the perennial variety is likely to be replaced eventually by superior annual types.

In Kerala, no separate variety has been evolved by the State for cultivation and hence improved varieties like Cambodia 2, M.C.U.1, Karunganni 2 and Karunganni 5 are grown in Trichur and Trivandrum districts adjoining Madras State.

The characters of the improved varieties recommended by the Agricultural Department are detailed in Tables 109, 110, 111 and 112. Plates XI and XII show the degree of improvement attained in the staple length of improved varieties of Cambodia and Karunganni cottons.

COTTON CULTIVATION

SEASON OF SOWING

The different rainfall patterns and soil types, the extensive facilities for lift irrigation and the existence of special varieties for particular seasons in the Southern Region have led to differing systems of cotton cultivation. They are also responsible for the growing of cotton practically throughout the year in some part or the other in the region. Cambodia cotton is grown both as a winter crop and as a summer crop. The former is planted in September-October and the latter in February-March when grown under irrigation, or in December as an unirrigated crop. Karunganni and Tinnies cottons are normally planted during the period from September to November and sometimes in December, depending on the incidence of rains and the type of the black soil on which it is grown. Nadam cotton which is perennial is sown in June-July. The Sea Island cotton on the West Coast is planted with the outbreak of the south-west monsoon in early June. The initial growing period of all cottons other than summer Cambodia, coincides with falling temperature and, therefore, the water stress during the vegetative phase is not very great. The plant growth of summer Cambodia takes place during a period of high temperature. The crop experiences severe water stress and has, therefore, to be irrigated frequently.

TABLE 109. PARTICULARS OF IMPROVED AMERICAN COTTONS (*G. hirsutum* race *latifolium*)

Item	Particulars			
Name of Variety	Cambodia 2	Madras Cambodia Uganda 1	9030G	Madras Cambodia Uganda 2
District of growth	Coimbatore, Salem, Tiruchirapally and Madurai	Coimbatore, Salem, South Arcot, Ramanathapuram and Tinnunelveli	Coimbatore, Salem, Tiruchirapalli and Madurai	Ramanathapuram, Tirunelveli and South Arcot
Suitable for planting as	Irrigated and unirrigated winter crop	Irrigated and unirrigated winter and summer crop	Irrigated and unirrigated winter crop	Irrigated summer crop
Normal yield of lint	(*a*) 250 to 300 lb. (*b*) 50 to 125 lb.	(*a*) and (*c*) 250 to 300 lb. (*b*) 50 to 125 lb.	(*a*) 250 to 300 lb. (*b*) 50 to 125 lb.	(*c*) 250 to 300 lb.
Staple length*	(*a*) and (*b*) 25/32″ to 31/32″	(*a*) and (*c*) 30/32″ to 1-1/32″ (*b*) 28/32″ to 1″	(*a*) and (*b*) 29/32″ to 1-1/32″	(*c*) 31/32″ to 1-1/32″
Ginning per cent.	33 to 34	33 to 38	35 to 38	34
Spinning value (H.S.W.C.)*	(*a*) 30's to 41's (*b*) 26's to 33's	(*a*) and (*c*) 52's to 54's (*b*) 37's	(*a*) 39's to 41's (*b*) 37's	(*c*) 44's to 52's
Estimated area in acres during 1955-56	83,737	2,24,670	This strain is under multiplication for release to the cultivators	20,312
Estimated production of lint during 1955-56 (bales of 392 lb.)	33,746	58,030	do.	5,443

(*a*) Irrigated winter crop.
(*b*) Unirrigated winter crop.
(*c*) Irrigated summer crop.
* As adjudged by the Technological Laboratory, Bombay.

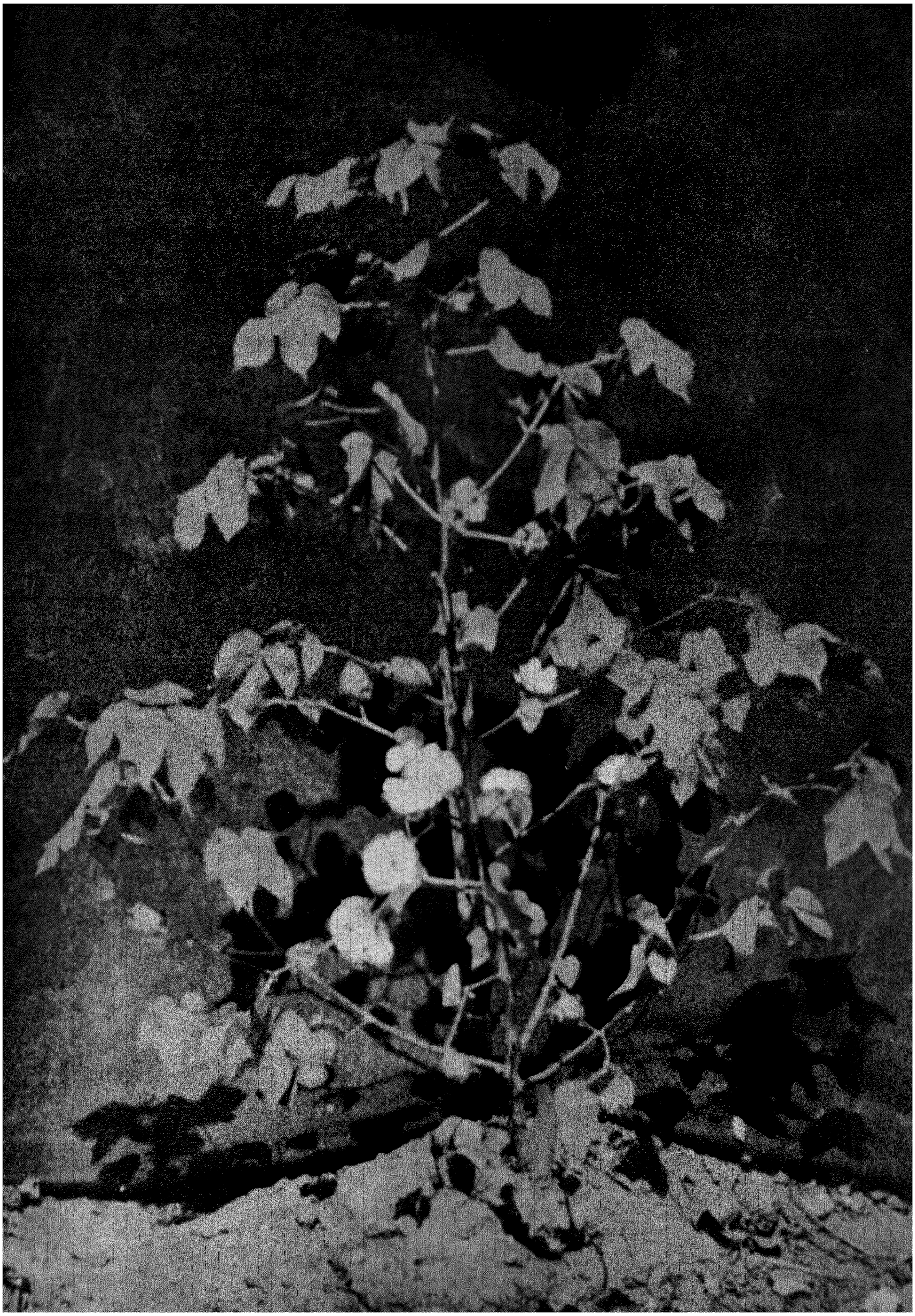
TABLE 110. PARTICULARS OF IMPROVED DESI VARIETIES (*G. arboreum* race *indicum*)

Item	Particulars		
Name of variety	Karunganni 2	Karunganni 5	6186-9
District of growth	Madurai, Ramanathapuram, Tirunelveli and Kanaya-Kumari	Coimbatore, Salem, Tiruchirapalli and parts of Madurai	The entire area of unirrigated *desi* comprising Coimbatore, Salem, Tiruchirapalli, Madurai, Ramanathapuram, Tirunelveli and Kanya-Kumari
Suitable for planting as	Unirrigated winter crop	Unirrigated winter crop	Unirrigated winter crop
Normal yield of lint	103 lb.	65 to 103 lb.	Not in large-scale cultivation*
Staple length†	26/32″ to 28/32″	26/32″ to 30/32″	27/32″ to 30/32″
Ginning per cent.	30 to 35	30 to 33	31 to 36
Spinning value (H.S.W.C.)†	28's to 33's	27's to 35's	30's to 36's
Estimated area in acres during 1955-56	2,24,670	1,19,866	This strain is under multiplication for release to cultivators
Estimated production of lint (bales of 392 lb.) during 1955-56	58,030	33,971	do.

† As per figures contained in the Technological Reports.

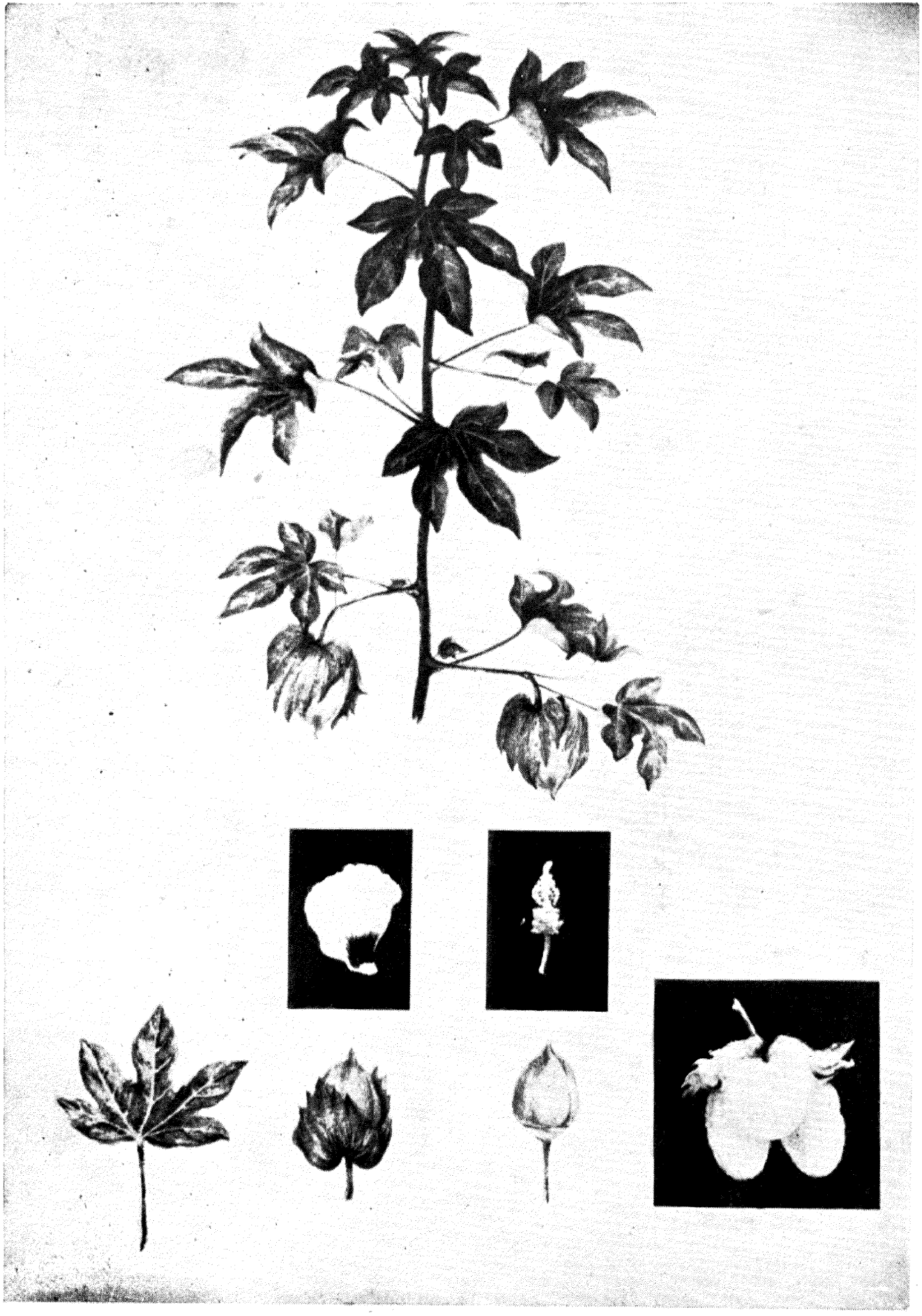
* The yield as recorded in comparative tests conducted in farmers' lands is higher than both Karunganni 2 and Karunganni 5.

PLATE IX



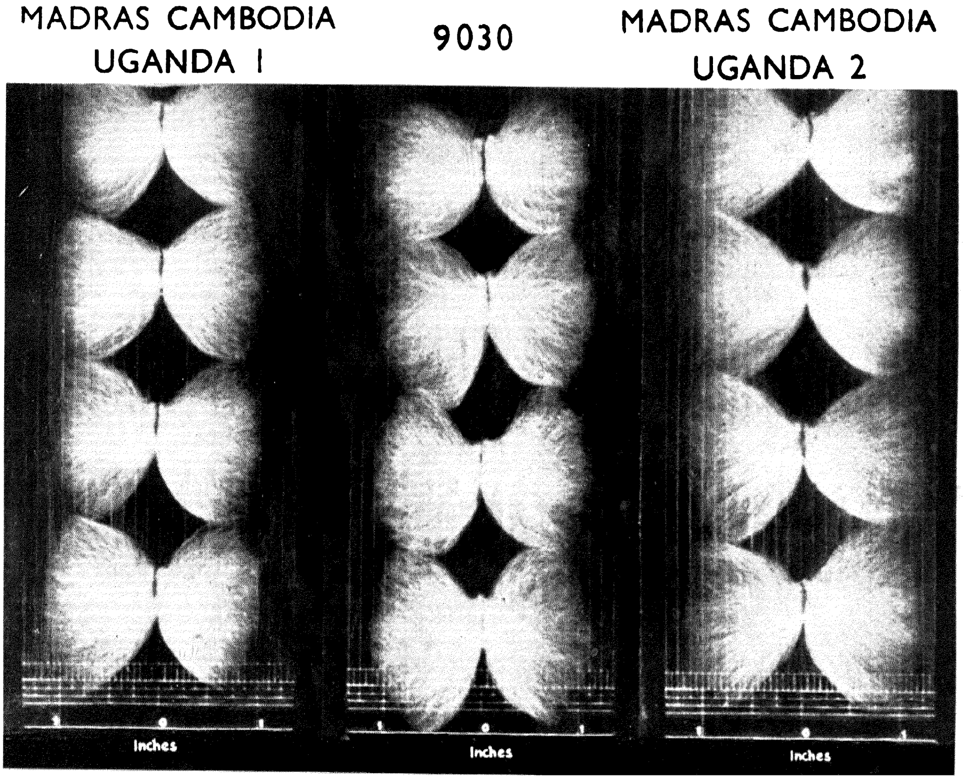
Typical 9030G Cotton Plant

PLATE X



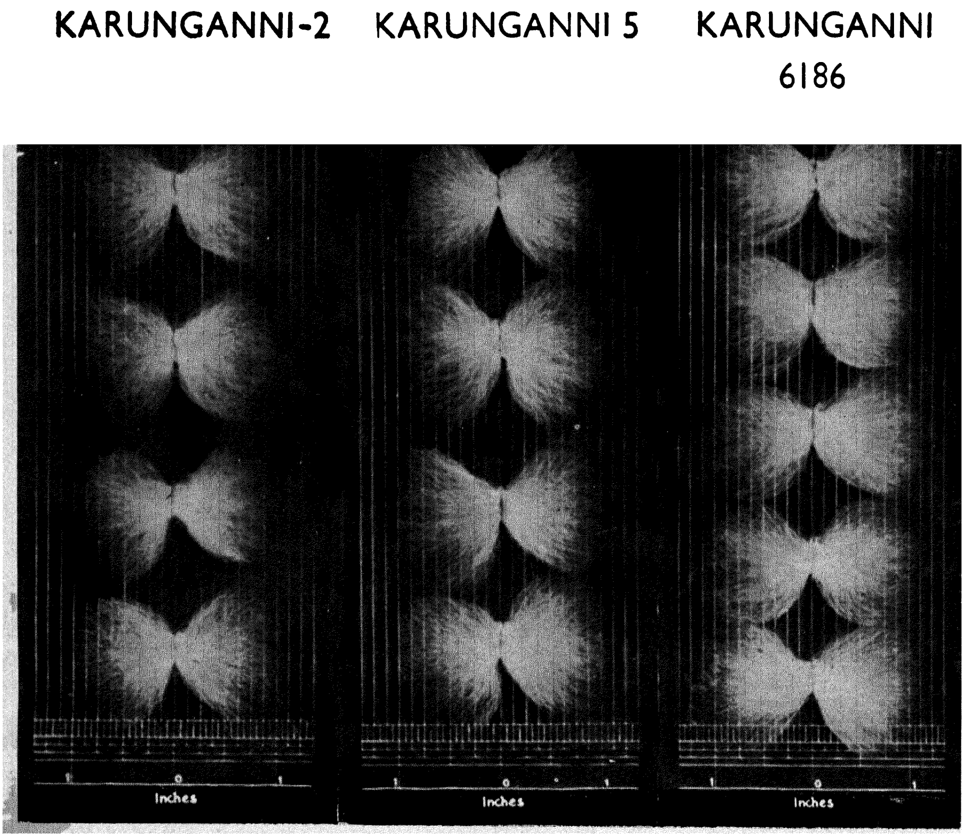
Characteristics of Karunganni 5 Cotton Plant

PLATE XI



Improvement in the Staple Length of Cambodia Cottons

PLATE XII



Improvement in the Staple Length of Karunganni Cottons

TABLE 111. DISTINGUISHING FEATURES OF IMPROVED AMERICAN COTTON VARIETIES

Item	Particulars			
Variety	Cambodia 2	Madras Cambodia Uganda 1	9030G	Madras Cambodia Uganda 2
Habit	Very vigorous; internodes long; late maturing	Vigorous; internodes short; early maturing	Vigorous; internodes medium, slightly later than M.C.U. 1 in maturity	Internodes long; early maturing
Crop period	(*a*) and (*b*) September-March (7 months)	(*a*) and (*b*) September-February (6 months); (*c*) March-August (6 months)	(*a*) and (*b*) September-February (6 months)	(*c*) March to middle of August (5 months); January to August in South Arcot (8 months)
Branching	One or two well-developed and strong vegetative branches at the base	Lesser number of vegetative branches and more of fruiting branches	More number of vegetative branches than M.C.U. 1.	Lesser number of vegetative and more fruiting branches than M.C.U. 1
Leaf	Large, dark green, five-lobed, lobes broad and flat, sinus open	Small, dark green, five-lobed, lobes medium and spoon-shaped, sinus overlaps at base	Medium large, dark green, five-lobed, lobes medium broad	Larger than that of M.C.U. 1, light green, five-lobed, lobes broader than in M.C.U. 1, raised sinus overlapping at base
Flower	Petal cream, pollen cream	Petal cream, pollen yellow	Petal cream, pollen yellow	Petal cream, pollen yellow
Bracts enveloping flower and fruit (boll)	Veins purple where exposed to sun	Veins green in winter crop but light purple in summer crop where exposed to sun	Veins green excepting in portions exposed to sun	Veins green, light purple in exposed portions
Bolls	Large, tending to droop downwards, 3 to 4 loculed	Small, tending to point upwards, 4 to 5 loculed	Small, 4 loculed	Narrow, tapering and acuminate, tip, sparsely pitted as in *barbadense*, 4 to 5 loculed
Seeds	Big, dense coating of white short hairs, tip pointed	Small, dense, coating of greenish short hairs, tip pointed	Small, fuzz, light greenish	Smaller than M.C.U. 1 with greyish fuzz, tip pointed
Lint colour	Dullish white	Bright white	White to creamy white	White to creamy white
Parentage	A pure-line selection in Cambodia cotton	An inter-*hirsutum* hybrid selection from A.12 (East Africa) × Cambodia 2 (Madras)	Derivative of a multiple hybrid involving *barbadense* (Ashmouni and Sea Island), *hirsutum* var. *marie galante* (Moco) and *G. hirsutum* (East African, Cambodia 2 and Russian)	Derivative of multiple-hybrid involving *barbadense* (Sea Island and *hirsutum* (East African and Cambodia 2)

(*a*) Winter crop irrigated. (*b*) Winter crop unirrigated. (*c*) Summer crop irrigated.

TABLE 112. DISTINGUISHING FEATURES OF IMPROVED DESI COTTON VARIETIES

Item	Particulars		
Variety	Karunganni 2	Karunganni 5	6186-9
Habit	Vigorous, tall, less branches and lax in body build; one or two basal monopodials	Vigorous and tall growing; pyramidal in shape	Vigorous, tall and sympodial
Crop period	October-May (8 months)	October-May (8 months)	October-May (8 months)
Branching	Very few vegetative branches	Two or three vegetative branches on the basal portion	Very few vegetative branches on basal portion and more of fruiting branches above
Pigmentation of the stem	Purple	Purple assuming a deeper tinge with plant growth	Purple
Hairiness	Sparse	Sparse	Sparse
Leaf	Large, dark green, five-lobed, lobes medium broad, petiole prominently purple on the side exposed to sun	Large, dark green, five-lobed, lobes medium broad tending to be narrow, petiole light purple on the side exposed to sun	Medium, green, five-lobed, lobes narrow petiole purple on exposed portions
Nectaries	Present on the underside of the leaf	Present on the underside of the leaf	Present on the underside of the leaf
Flower	Petal yellow with dark purple spot at the base; pollen yellow; filaments purple pigmented	Petal yellow with dark purple spot at the base; pollen yellow; filament purple pigmented	Petal yellow with dark purple spot at the base; pollen yellow; filament purple pigmented
Bracts enveloping the flower and fruit (boll)	Very large, deep, purple on sides exposed to sun; accresent completely covers the flower and boll; no teeth on the margin	Medium; lightly pigmented on sides exposed to sun; partly covers the boll; margins deeply cut	Small, purple on exposed surface; does not cover the bolls; vestigial teeth on margins
Bolls	Large, tapering, longer than broad; three loculed; surface pitted	Large, broad at base with prominent shoulders; three to four loculed	Medium, longer than broad tapering; three to four loculed
Seeds	Small, tapering; light coating of greyish short hairs	Small tapering; short whitish hairs on slightly greenish coat	Small, tapering; greyish fuzzy
Lint colour	Pearly white to white	Creamy white to white	Pearly white to white
Parentage	Derivative of hybrid family involving *indica* (Nandyal 14 and Cocanadas 49 and *cernuum* (Garo Hill cotton)	Derivative of hybrid family involving *indica* (Nandyal 14 and Cocanadas 49) and *cernuum* (Garo Hill cotton)	Derivative of hybrid family, involving *indica* (Nandyal 14, Cocanadas 49 and Karunganni) and *cernuum* (Garo Hill cotton)

Cambodia cotton in South Arcot district is planted in March and irrigated from wells in the same manner as the summer cotton grown in other parts of the State. The crop, though apparently good in growth and vigour is generally disappointing in yield. In addition, it suffers from imperfect boll opening and poor seed viability. Liberal applications of manure and irrigation failed to correct the defects. Closer observation of the phenomena revealed that flower drop, resulting from the improper formation of pollen grains during spells of high atmospheric temperature, was the chief cause for low yields. The same factor caused increase in motes, improper development of seeds and defective boll opening. Among the various measures tried for removal of these defects, early planting in December proved the most effective. Crop sown in December yielded thrice as much as the crop sown in March. The boll opening and seed development of the early sown crop were also much better.

ROTATION

The irrigated winter Cambodia is grown after *jowar*, *bajra* or finger millets which occupy the land from March to September. The summer crop grown under irrigation follows rice in tank-fed and canal regions, and water is drawn from supplementary sources like wells or filter-point tube-wells. The unirrigated Cambodia is usually planted after a crop of *jowar*, *bajra* or groundnut.

The common rotations in the black soil area are: (*i*) cotton-*bajra*-cotton-fodder-*jowar* in Ramanathapuram, Tirunelveli and Madurai districts; and (*ii*) cotton-grain-*jowar* or *bajra*-gram in Coimbatore, Salem and Tiruchirapalli districts. Small cultivators grow cotton year after year on the same land, while the bigger farmers rotate it with one or more cereal crops, or practice a three-course rotation, including a legume. Many rich farmers grow *bajra* annually by manuring the lands heavily and take cotton as a second crop in the same year. Cotton raised on such lands makes rank vegetative growth.

Some dry land farmers grow cotton mixed with groundnut, red gram, millets or castor. Similarly, some cultivators in Ramanathapuram and Tirunelveli districts raise Cambodia cotton as a mixture with irrigated finger millets. Finger millet seedlings are transplanted in August-September in beds while cotton is dibbled at the same time in the beds as well as on the sides of ridges. Sometimes, cotton seeds are sown broadcast, beds formed and finger millets transplanted. The cereal outgrows cotton rapidly and is harvested in January. Thereafter, the cotton is given a hoeing and earthing to which it responds remarkably well. The harvest of cotton is completed by the end of March. Such intensive mixed cropping is feasible on fertile irrigated soils only.

Nadam cotton is always grown mixed with cereals during the first year, while catch crops like horse gram are taken in the second and third years, if the season is favourable.

PREPARATORY CULTIVATION

The land for Cambodia cotton is usually given four ploughings to secure a good tilth. When iron mould-board ploughs like Victory plough is used, two ploughings will do. The fields so prepared are sometimes thrown into ridges and furrows (30″ apart) with either a ridging plough or a junior hoe equipped with ridging attachment. In the case of late sown Cambodia following a crop of finger millets, which is harvested at the end of September, there is no time for preparatory cultivation. Cotton seed is broadcast and covered by working a country plough, and the soil is thrown into beds with *mammoty* (a broad blade attached to a wooden handle).

The preparation of black soils for growing Karunganni cotton begins after a shower in June. Three ploughings are normally sufficient, but when the land is weedy, it is ploughed one or two times more. The last ploughing is done in September (a week or two before sowing) leaving open furrows at regular distances in the field to catch the rain water.

Nadam cotton grown on light gravel bearing soils, receives three ploughings after a good soaking rain in May-June.

METHOD OF SOWING

Most of the farmers in Cambodia tract sow the seeds broadcast, cover with country plough and form beds for irrigation. In spite of propaganda and demonstration by the State Agricultural Department, line planting and furrow irrigation have not gained much favour except in the early planted winter Cambodia zone, where water stress is a limiting factor and where sufficient time is available for preparing a good seed bed. In the unirrigated Cambodia area, the method of scattering seeds with hand and covering with plough is a rule.

In the black soil dry lands, broadcasting the seed in flat is largely in vogue. Line sowing with seed drills has not been adopted in spite of intensive demonstration of the practice by special staff. Although the seed is generally sown in moist land it is sometimes broadcast in dry soil, particularly if the sowing rains are delayed. In some of the parts, half the quantity is sown and covered by plough and the remaining half is broadcast but allowed to remain on the surface. These variations are intended to counteract the effects of uncertain and insufficient rains, especially in stiff black soils. In the case of mixed crops, the components are sown broadcast in the same manner as cotton but subsidiary crops like coriander are sown in lines behind a plough.

The seeds for sowing are passed through a fine mesh country cot to remove the adhering lint. They are then rubbed with a thick mixture of water, cattle-dung and red earth, to free them from each other. The treated seeds are dried for a short period before sowing. In cases of unexpected delay, the treated seeds are fully dried and temporarily stored in a dry place. In localities infected with white ants, quick lime powder of *vasambu* (*Acorus calamus*) dust is mixed with sowing seed before planting.

SEED RATE AND SPACING

The optimum spacing for irrigated Cambodia is 30 inches between rows and four to nine inches between plants in the row, depending on whether the crop is sown late or early. Twelve pounds of seeds per acre for early planting and 28 pounds for late sowing are the normal rates. The recent trend is in favour of close planting even with the early sown crops. This is possibly a direct result of the introduction of early maturing varieties which do not grow as vigorously as Cambodia 2. Thick sowing followed by the necessary thinning is invariably practised for crops sown late or grown on poor land.

In the Karunganni and Tinnies area, about 10 lb. of seed per acre is sown broadcast. This allows about one square foot of space for each plant.

INTERCULTURE, WEEDING AND THINNING

Since cotton is mostly sown broadcast, it is usually hand-weeded and hand-hoed. In crops sown in lines, hoeing and ridging are done with bullock-drawn planet junior hoes. Two *mammoty* hoeings and one or more hand weedings constitute the general practice in many areas. Thinning is rarely practised but when found indispensable, a country plough is worked through the crop to dislodge some of the young seedlings. Sometimes, an irrigated crop is thinned by giving it a deep *mammoty* hoeing. Nadam cotton receives ploughing after heavy shower as this practice is supposed to produce fresh waves of flowering.

MANURING

Generally, the cotton crop is not manured directly. The usual practice in irrigated Cambodia area is to manure the preceding cereal crop heavily with a mixture of cattle manure and tank silt in the proportion of 1:3. In the intensively cultivated Coimbatore district, it is not unusual to find the rotation crop of finger millet being manured with 50 tons of cattle manure. Generally, however, the rate of manuring is much less and varies with the financial resources of the cultivator and the irrigation facilities available.

Fertilizer investigations conducted in Madras State have shown that a split application of groundnut cake or ammonium sulphate to supply 40 lb. of nitrogen per acre, half at sowing time and half at the flowering stage, increases the yields of irrigated Cambodia by 200 lb. of *kapas*. It has also been found that the best method of applying ammonium sulphate is to broadcast 112 lb. of the fertilizer before ridging the field for planting and an equal quantity at the time of hoeing the crop in December. For cotton planted in the standing stubble of finger millets, it is advisable to apply the first dose in December and the second dose in January. Irrigation should invariably follow each application.

In dry black soils, manure is always applied to the cereal crop in rotation and preferably to the better class of moisture-retentive lands. Cotton benefits indirectly from the residual effects of manuring. It is generally believed that direct manuring of the fibre crop encourages only vegetative growth. In the experiments at the Agricultural Research Station, Koilpatti, however, the broadcast basal application of 20 lb. of nitrogen per acre in the form of ammonium sulphate to unirrigated Karunganni cotton increased its *kapas* yield by 70 lb. on soils of medium fertility and at twice that rate on soils highly fertile.

Weed infested soils are not manured with cattle-dung mixed with village refuse as the latter is said to encourage the spread of nut grass. Such lands are usually sheep-folded in January or September (for summer or winter crop). The penning of 1,000 sheep for a day is usually deemed sufficient to manure one acre.

Nadam cotton is manured by sheep-folding or the application of village refuse.

As to the economics of manuring, extensive enquiries from cultivators showed that the manuring of irrigated Cambodia with chemical fertilizers costing Rs. 35 per acre produced an increased yield worth Rs. 100. The corresponding figures for rainfed Karunganni cotton were Rs. 17 and Rs. 30 per acre, respectively.

Another significant indication of these enquiries was that manuring of cotton was worthwhile even in adverse seasons. Recovery of crop after rains following prolonged dry weather or after an epidemic of injurious insects was more obvious on manured land than on unmanured soil. Such beneficial effects persisted even in the second (summer or *kar*) pickings of Karunganni cotton taken in May-June. Hence, it is to be concluded that direct manuring of cotton in Madras would prove a sound practice.

IRRIGATION

The water requirements of winter and summer Cambodia are different and are conditioned by the incidence of north-east monsoon or summer rains and the air temperatures during periods of plant growth. The winter crop benefits from the north-east monsoon and, hence, requires less irrigation than the summer crop. The interval between successive irrigations is usually one week, but it varies greatly with the severity of the season and availability of water in wells. The experimental data collected at Coimbatore indicated that irrigation once in three weeks was sufficient, but in sandy soils and for summer crop, more frequent irrigations were needed. Copious irrigation during the flowering and ripening phases induced good boll setting and high fibre maturity. Other conclusions derived from the above experiments were: (*i*) irrigating once a week was wasteful and uneconomical; (*ii*) a good crop of Cambodia could be taken with two irrigations after the closure of a normal north-east monsoon; (*iii*) more water per irrigation was absorbed when the interval between two successive irrigations become longer, but the relation was not directly proportional; (*iv*) the manured plots consumed more water than the unmanured plots; (*v*) plant to plant spacing in the row did not influence the water requirements of the crop; (*vi*) waterings given at the flowering phase were more important than those given at regular intervals irrespective of the plant development stages; (*vii*) the normal water requirements of Cambodia from sowing to harvest ranged from 23 to 36 acre-inches; and (*viii*) three acre-inches of water applied once in two or three weeks was the most economical.

In some parts of Coimbatore and Madurai districts, Karunganni cotton, growing on black soil and containing a large proportion of coarse fractions, is given a few irrigations, particularly at the time of flowering. Yields up to 1,000 lb. of *kapas* per acre have been recorded for such crops.

Except in the tracts recently brought under the Lower Bhavani Project, the bulk of irrigated Cambodia depends for its water supply on wells and filter-points. Oil engines, electric motors and bullock driven *mhotes* (water lifts) are installed depending on the finances of the land owner and the availability of water. With the supply of cheap electricity for agricultural purposes, digging of huge deep wells, has been very much in evidence in Coimbatore district. It is not uncommon to find well-to-do progressive farmers investing huge capital, amounting sometimes to Rs. 50,000 in deepening wells, using boring sets to tap the underground water and installing deep-well submersible pump-sets for irrigating their lands day and night. Continuous pumping, though remunerative, has lowered the water table in wells a great deal, making it difficult for the small farmer to survive, unless he emulates the example of his richer neighbour.

The installation of filter-point tube-wells in the Cauvery delta has proved a great success. The sub-stratum of sand, occuring 20 to 50 feet below surface, supplies copious quantities of water continuously during the off-season when the canals remain closed. The problems of canal irrigation for cotton in the Lower Bhavani Project have yet to be solved. The land slope in this project area is steep and the soils are shallow, poor and open in texture.

The cultural practices for cotton grown in Kerala State are not very different from those followed in Madras.

DISEASES AND PESTS

Diseases and pests cause a loss of about 10 per cent. of the annual production. In addition, they lower the quality of the fibre through stains and increased immaturity. The exotic varieties and their derivatives are more susceptible than the indigenous races of *G. arboreum*. The evolution of varieties capable of resisting or dodging the attack wholly or partially, modifications in the agronomic practices, application of fungicides and pesticides to seed and plant, and enactment of legislation to ensure a 'no-cotton' period to starve the insects constitute the main control measures adopted in the region.

DISEASES

Blackarm, root rot, wilt and anthracnose are the principal diseases affecting cotton in this area. Blackarm (*Xanthomonas malvacearum*) has been responsible for the discontinuance of the cultivation of many quality cottons like 920, Cambodia 3 and Cambodia 4. The disease became widespread especially after the introduction of exotic Uplands and their extended use in hybridisation. Even the indigenous varieties, Karunganni 1 and Westerns 1, which were free until then, began to be affected by the disease. Breeding and screening of varieties for blackarm resistance have become an established routine in cotton improvement work.

The diseases occur as angular leaf spot, blackarm and bacterial boll rot, depending on the plant part affected. It is seed-borne, and the infected plant debris is often a rich source for the secondary infection. External agencies like wind, sharp rain, cloudy weather and sheet erosion assist the spread. Delinting of seed with sulphuric acid and treatment with organo-mercury compound prevents primary infection, but there is no satisfactory control over secondary infection in a bad year. Breeding of resistant varieties seems to be the only way out. During the course of studies made in this connection, varieties reputed to be resistant or immune in other countries were found to breakdown at Coimbatore, while the Selection 2196 derived from an interspecific American-Asiatic hybrid at Surat proved highly resistant. These observations go to show that physiological forms of blackarm exist and that each cotton region must undertake work on blackarm resistance based on the local ecological conditions.

Root Rot (*Rhizoctonia bataticola* — *Macrophomina phaseoli*): This attacks young as well as old plants in the Karunganni area and causes them to wilt. The isolates from cotton were able to infect other host plants like horse gram, green gram, etc. The damage to cotton is not recurrent but seasonal, in certain years. Experiments have shown that the fungus does not remain viable in the soil for more than a year. Hence, crop rotation offers an effective method of control.

Wilt (*Fusarium vasinfectum*): This is confined to Karunganni cotton in a portion of Coimbatore district. The evolution of resistant varieties is the only effective control measure.

Anthracnose (*Collectotrichum sp.*): This causes seedling blight and boll rot in Karunganni and Uppam varieties in Coimbatore and Tirunelveli districts.

It is very destructive in wet years, and causes a loss of 48 per cent. in seed cotton and 10 per cent. in ginning outturn.

The organism harbours on the infected seed. Seed treatment with organo-mercury compounds and sulphuric acid has proved effective. Spraying Bordeaux mixture on seedlings and bolls, especially during moist weather, checks the spread of disease.

Leaf Spot (*Alternaria macrospora*) and *Areolate Mildew* (*Mycospharella areola — Ramularia areola*): These are two minor diseases. Severe infection causes defoliation and can be controlled by Bordeaux mixture sprays.

PESTS

Among the various insects which attack cotton in the Southern Region, bollworms, jassids, stem weevil, stainers, leaf roller and plant lice are the most important. During recent years, the growers of quality cottons under irrigation have become conscious of crop losses caused by insect pests and have readily adopted the use of pesticides.

Spotted Bollworms (*Earias insulana* and *Earias fabia*) and *Pink Bollworm* (*Platyedra gossypiella*): These cause the greatest damage. The principal measures recommended for their control are: (*i*) removal and destruction of shoots and buds attacked by spotted bollworm; (*ii*) avoiding cultivation of *bhendi* (*Hibiscus esculantus*), which is an alternative host of spotted bollworm, in the off-season; (*iii*) the fumigation of sowing seed with carbon bisulphide or methyl bromide against pink bollworm; (*iv*) regular application of endrine and folidol to the standing crop against both the insects; and (*v*) the early removal of cotton stalks at the end of the season to prevent continuous breeding of the pests.

Stem Weevil (*Pempherulus affinis*): This is next in importance to bollworms. In years of severe attack, the plant mortality caused by this pest is as high as 40 per cent. In the early years of Cambodia cultivation, the cultivators kept the crop on the ground for more than one year, thus encouraging pest activity and causing heavy crop losses. To counteract this, the Madras Government extended the application of the Madras Agricultural Pests and Diseases Act, 1919, to cotton. The Act required the compulsory removal of *hirsutum* cotton in the notified areas of Coimbatore, Salem, Tiruchirapalli and Madurai districts before a specified date, so as to create a 'no-cotton' period of at least one month before planting the next cotton crop. However, the subsequent extension of the date of the plant removal and the frequent grant of exemptions almost nullified the good effects of the Act. Work for the production of varieties resistant to stem weevil was, therefore, taken up. The Bourbon cotton which resisted the pest by gall development, and Moco cotton, which killed the grub by gum exudation, were crossed with other varieties and a new strain, 9030, possessing a high degree of resistance to stem weevil was evolved. As mentioned already, the seed of this new variety is being multiplied for the extension of its culivation.

Jassids (*Empoasca devastans*): This has assumed a major importance in recent years, especially in areas where Cambodia cotton is cultivated. Summer Cambodia suffers little damage and the Asiatic cottons are practically free from attack. Though hairy types are usually resistant, only a few of them maintain their ability in changed environments. Quick-growing hairy varieties planted thick, early in the season, dodge the pest attack fairly satisfactorily. Jassids can also be controlled effectively by dusting or spraynig the crop with DDT.

Plant Lice (*Aphis gossypii*): This causes severe damage to exotic cottons, but can be controlled by spraying the crop with tobacco decoction, BHC, HEPT, etc.

Red Cotton Bug (*Dysdercus cingulatus*) and *Dusky Cotton Bug* (*Oxycarenus laetus*): These are two minor pests which cause occasional damage.

Other pests of minor importance are leaf roller (*Sylepta derogata*), shoot weevil (*Alcides affaber*), mealy bug (*Pseudococeus irrigatus*), flea bettle (*Monolepta signata*) and thrips (*Thrips tabaci*). Removal and destruction of affected parts and application of pesticides are recommended as control measures.

HARVESTING AND YIELD

As all the bolls do not mature simultaneously, the harvesting of the crop continues for two or three months, depending on the variety, season and type of cultivation. In irrigated winter Cambodia, pickings last from January to March, while those of the unirrigated winter crop may continue till June-July, particularly in years of good summer rains. The harvest of summer irrigated Cambodia begins in June and is completed before August. The unirrigated Karunganni cotton, which is generally sown late (September-October), is harvested from February to May. The harvest of Nadam is usually a long drawn process, depending entirely on the incidence and sufficiency of rains during its growth phases. Being a perennial variety, it has the capacity to produce fresh flowers after every shower and to yield more than one crop in a year. The Sea Island cotton grown on the West Coast produces ripe cotton from September to November, depending on the time of planting.

The first and second pickings are generally small in quantity and poor in quality due to immaturity of fibres. The last picking is also of poor grade, being damaged and stained by insects and diseases. The mid-season pickings are usually the best. The crop is picked by women and juvenile labour who work from morning to evening with a short break for the mid-day meal. When a sufficient quantity is collected, the cotton is deposited on the ground in a corner of the field until the end of the day, when it is apportioned between the farmer and labourers who receive wages in kind. The labourers' share ranges from 1/6 to 1/12 during peak period and is around 1/3 during the first and last pickings and in lean harvests. As payment in kind fails to remunerate an average worker adequately and as the labourers pay no attention to clean pickings under this arrangement, the payment of wages in kind is, in recent years, being replaced by cash wages.

The grower is not guilty of malpractices, like deliberate exposure to dew and rain or admixture of foreign matter in order to gain weight. However, harvesting in the hot sun, when the broken leaves and bracts get mixed with seed cotton, heaping of produce in field exposed to wind-tossed foreign matter, and the pooling of the low grade first and last pickings with good quality main harvest, lowers the quality and the price of the entire produce. In some parts of Salem district, harvesting of green bolls and drying them in sun to force dehiscence are in vogue. The two main reasons for this practice are: (*i*) fear of theft of *kapas* in fields situated far away from villages; and (*ii*) increased cost of production on small holdings due to frequent pickings, especially in the Final stages. However, with the establishment of regulated markets and the system of certification of produce, enabling the growers to realise a special premium for good quality long staple cotton, the practice is on the wane. It is now restricted to areas in which removal of cotton stalks before August 31 has been made compulsory under the Pest Act. Extensive propaganda in favour of clean picking, storage on clean ground and sale of good and bad pickings separately has evoked no response. However, the practice of pre-cleaning *kapas* in the ginning factories improves its grade to some extent, thereby fetching a higher price for the produce and ensuring clean cotton to the textile mills.

The average yield of cotton in the region varies with the variety, the system of cultivation and the time of planting. Due to better manuring, early planting, use of improved seed and timely pest control, the yields of irrigated winter and summer Cambodia have gone up in recent years. Although the normal yield for such cotton in Madras State ranges from 250 to 300 lb. of lint per acre, high yields touching 900 lb. lint are not uncommon. Unirrigated Cambodia has a normal yield of 100 to 125 lb. of lint per acre, depending on season and soil fertility. The Karunganni and Tinnevellies yield about 100 lb. of lint per acre.

MARKETING AND GINNING

The bulk of the produce is sold as unginned cotton or *kapas* since the average holding of an individual farmer is only about 2.5 acres and since the produce obtained therefrom is small. A number of intermediary agencies function in getting the cotton to ginning factories and in selling the lint to the consuming mills. The grower in the village sells his cotton to one or other of the following agencies: (*i*) creditors who have advanced money; (*ii*) village merchants; (*iii*) itinerant dealers; and (*iv*) agents of ginneries. In the assembling markets, the sale may be to: (*a*) merchants in regulated markets; (*b*) traders in unregulated markets; (*c*) co-operative societies; and (*d*) textile mills. Only 15 per cent. of the produce is reported to be purchased by village money lenders in Tinnevelly area and very much less in other tracts. One reason for the money lenders handling only a small part of the produce is that the well-to-do landlords in the villages offer credit facilities without actually buying the cotton. The direct purchasers are, therefore, the village merchants, itinerant dealers and ginning factory agents. In the Cambodia tract, the last category of buyers secures nearly 30 per cent. of the production by offering better prices, by foregoing a portion of the profits earned from the ginning industry. About half of the produce is marketed through commission agents operating in regulated markets and advancing money on pledged cotton, while the remaining quantity is handled by the village merchants. In the Tinnevelly area, comprising the districts of Madurai, Ramanathapuram and Tirunelveli, only a quarter of the produce is brought to the market directly by the growers, the remainder being sold through agents of buying firms and textile mills. The average grower does not consider it worthwhile to carry the small quantity of cotton produced by him to the *urban* market but prefers to sell it ex-farm house for spot cash. The village money lenders, rich landlords, and shop keepers secure cotton business by advancing money to growers on the condition that the latter would sell their produce to them to clear outstanding debts. The supplies to the agents of consuming mills and wholesale or export traders are made by village dealers, through brokers.

Ginning factories operating in villages are also engaged in the purchase of *kapas* as most of them are owned by rich merchants and commission agents of millowners. The commission agents operate in *urban* centres and arrange sale on commission. They own or hire godowns and advance money to village merchants and *ryots* on interest. They bargain with buyers and advise sellers for the best price.

Some co-operative societies own ginning factories. Besides functioning as credit and marketing agencies, they assemble the cotton of individual members without pooling. Some of them also engage in pure seed multiplication and distribution work.

The Madras Agricultural Department helps the marketing of cotton produced on farms operating under its control for the multiplication of improved seed. It purchases the cotton needed by Government jails or *khadi* centres and certifies the purity of improved produce, which under this arrangement often fetches a premium of Rs. 100 to Rs. 200 per candy of lint over uncertified cotton.

Large textile and spinning mills set up their own buying agencies in the cotton-growing areas for direct purchase of such cotton, especially in the years of inadequate production.

The village merchants generally offer a high price and then off-set it by faulty weighments. In the districts where weekly *shandies* (markets) are held regularly, the small growers and the labourers receiving wages in kind bring cotton in *gunny* loads. In their anxiety for quick cash sale, they are often duped by merchants in both price and weight. In private unregulated markets, the commission agents charge commission from both the buyer and the seller. The seller has also to pay for handling and weighing, besides furnishing samples and contributing to charity.

In the regulated markets, the market charges are fixed by market committees. It has been estimated that in selling through middlemen in unregulated markets, the grower pays Rs. 12.63 as market charges for Karunganni and Rs. 13.63 for Cambodia as compared to only Rs 3.75 per *pothi* of 280 lb. sold in regulated markets. As between the co-operative societies and commission agents, the charges payable to the latter are high in both the cotton tracts.

	Salem Cambodia (per unit of 305 lb.)	Tinnevellies (per unit of 247 lb.)
Commission Agent	Rs. 4.47	Rs. 4.25
Co-operative Society	Rs. 2.06	Rs. 3.06

With the extension of the Madras Commercial Crops Market Act to the entire zones of Cambodia and Tinnevellies, and the establishment of regulated markets in all cotton-growing districts, many of the defects enumerated above are expected to disappear, thereby enabling the growers to realise the intrinsic price of their produce.

The ginning of seed cotton is done by mechanically powered roller gins. No saw gins have been installed in this region. As mentioned already, both Cambodia and Karunganni seed cotton are cleaned in the gins to remove stained and immature locks and to make the produce suitable for mixing with good quality imported cotton used for spinning fine yarns of 40's counts and over. Hand gins found in some villages, are used mostly for separating the lint required for manufacturing *khadi.*

ECONOMICS OF COTTON PRODUCTION

The economics of growing cotton varies with the variety grown and the systems of farming practised. The cultivation costs in different areas have been influenced in a varying measure by one or more of such factors as the post-war rise in the cost of human and cattle labour, particularly in the vicinity of industrial towns, the expanding use of the tractor cultivation in some areas, the high price of fuel and oil, the low cost of electric power where ever available, increased provision of cheap flow irrigation, the substitution of line sowing by broadcasting of seed in some tracts, the adoption of the ridge system of cultivation for irrigated cotton, and the regular employment of costly crop protection measures for the Sea Island variety. A uniform estimate of cost of production for different varieties or tracts, is, therefore, not practicable. Separate estimates of cost for the cultivation of Cambodia, Punjab 216F, Karunganni and Sea Island varieties under irrigated or rainfed conditions (as the case may be) are given in Tables 113 (*a*) to (*f*).

TABLE 113a. ESTIMATED COST OF CULTIVATION AND INCOME PER ACRE OF IRRIGATED WINTER CAMBODIA

Item of cultivation	Labout units			Cost (Rs.)
	Cattle (pairs)	Men	Women	
Total Cost :				
Preparatory cultivation:				
Ploughing, ridging and forming beds	3	7	—	16·00
Sowing:				
Dibbling or broadcasting and covering	1	3	10	11·00
Inter-cultivation:				
Thinning, weeding and hand hoeing inclusive of two *mammoty* hoeings by men	—	8	14	15·00
Irrigation:				
Eight irrigations	—	16	—	16·00
Manuring:				
Spreading fertilisers and covering	2	4	4	12·00
Plant protection:				
Application of pesticides—three rounds	—	2	2	3·00
Harvesting:				
Ten pickings	—	—	40	20·00
Post-harvest:				
Removing cotton stalks	1	2	—	5·00
Cost of materials:		Rs.		
Residual effect of cattle manure applied to previous cereal crop, 10 tons at Rs. 6 per ton		60·00		
Ammonium sulphate two cwts.		34·00		
Seeds at 24 lb. per acre		4·00		
Pesticides and fungicides		20·00		
Cost of power for irrigation		30·00		
		148·00		148·00
		Total		246·00
Total Receipts:				
Value of 900 lb. of *kapas* at 50 nP. per lb.				450·00
Value of cotton stalks per acre				10·00
				460·00

Net Profit : Rs. 460 *minus* Rs. 246=Rs. 214

TABLE 113b. ESTIMATED COST OF CULTIVATION AND INCOME PER ACRE OF IRRIGATED SUMMER CAMBODIA

Item of cultivation	Labour units			Cost (Rs.)
	Cattle (pairs)	Men	Women	
Total Cost :				
Preparatory cultivation:				
Ploughing, .breaking clods and forming beds and channels	4	8	—	20·00
Sowing:				
Thinning and gap-filling	—	—	11	5·50
Inter-cultivation:				
Weeding and hand hoeing (twice)	—	—	20	10·00
Mammoty hoeing	—	5	—	5·00
Rectifying beds and channels	—	2	—	2·00
Irrigation:				
Ten irrigations	—	30	—	30·00
Manuring:				
Spreading cattle manure	—	4	—	4·00
Top-dressing ammonium sulphate (two times at one cwt. each)	—	—	4	2·00
Plant protection:				
Three rounds	—	1	2	2·00
Harvesting:				
Ten pickings	—	—	40	20·00
Post-harvest:				
Removing cotton stalks	—	4	—	4·00
Cost of materials:		Rs.		
Cattle manure, 10 tons at Rs. 6 per ton		60·00		
Ammonium sulphate, two cwts.		34·00		
Seeds, 24 lb. at six lb. per rupee		4·00		
Pesticides and fungicides		20·00		
Cost of power for irrigation		30·50		
		148·50		148·50
		Total		253·00
Total Receipts:				Rs.
Value of 900 lb. of *kapas* at Rs. 54·4 nP. per lb.				490·00
Value of cotton stalks				10·00
				500·00

Net Profit : Rs. 500 *minus* Rs. 253=Rs. 247

TABLE 113c. ESTIMATED COST OF CULTIVATION AND INCOME PER ACRE OF 216F COTTON GROWN IN RICE FALLOWS

Item of cultivation	Labour units Cattle (pairs)	 Men	 Women	Cost (Rs.)
Total Cost:				
Preparatory cultivation	—	—	—	—
Sowing:				
Dibbling seeds and covering	—	—	20	10·00
After cultivation:				
Thinning, hoeing, removing stubbles, earthing up and weeding	—	30	60	60·00
Irrigation:				
Five times—guiding water	—	10	—	10·00
Manuring:				
Spreading ammonium sulphate and covering	—	6	4	8·00
Plant protection:				
Five sprayings of pesticides	—	10	20	20·00
Harvesting:				
Picking	—	—	60	30·00
Post-harvest:				
Puddling and pulling out stalks	—	2	10	7·00
Cost of materials:		Rs.		
Ammonium sulphate two cwts.		34·00		
30 lb. seeds		5·75		
Pesticides and fungicides		32·25		
		72·00		72·00
		Total		217·00
Total Receipts:				Rs.
Value of 800 lb. of *kapas* at 50 nP. per lb.				400·00
Value of cotton stalks				7·00
				407·00

Net Profit: Rs. 407 *minus* Rs. 217=Rs. 190

TABLE 113d. ESTIMATED COST OF CULTIVATION AND INCOME PER ACRE OF UNIRRIGATED WINTER CAMBODIA

Item of cultivation	Labour units Cattle (pairs)	 Men	 Women	Cost (Rs.)
Total Cost:				
Preparatory cultivation:				
Ploughing with country plough twice	3	3	—	12·00
Sowing:				
Sowing and covering	2	3	2	10·00
Inter-cultivation:				
Three weedings	—	—	12	6·00

Harvesting:				
Six picking (wages paid in kind)	—	—	36	18·00*
Post-harvest:				
Removing cotton stalks	—	10	—	10·00
Cost of material:				
18 lb. of seeds	—	—	—	3·00
		Total		41·00

Total Receipts:

Value of 375 lb. at 33·3 nP. per lb. (excluding the quantity of *kapas* paid as wages in kind)	135·00
Value of cotton stalks	6·00
	141·00

Net Profit: Rs. 141 *minus* Rs. 41 = Rs. 100

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* Not included in expenditure since the payment is in kind.

TABLE 113c. ESTIMATED COST OF CULTIVATION AND INCOME PER ACRE OF UNIRRIGATED KARUNGANNI

Item of cultivation	Labour units			Cost (Rs.)
	Cattle (pairs)	Men	Women	
Total Cost:				
Preparatory cultivation:				
Ploughing with country plough—three times	6	6	—	24·00
Sowing:				
Sowing and covering (inclusive of black gram and coriander crops sown mixed)	2	4	2	11·00
Inter-cultivation:				
Three hand weedings and one *mammoty* hoeing	—	8	18	17·00
Harvesting:				
Inclusive of subsidiary crops (paid in kind as seed cotton)	—	2	36	20·00*
Post-harvest:				
Pulling out cotton stalks	—	15	2	16·00
Cost of materials:				
12 lb. of cotton seed and subsidiary crops seed used for sowing	—	—	—	7·00
	Total			75·00

Total Receipts:

	Rs.
By sale of *kapas* 300 lb. at 41·7 nP. per lb. (excluding the quantity of *kapas* paid as wages in kind)	125·00
Value of cotton stalks	7·00
By sale of produce from subsidiary crops	43·00
	175·00

Net Profit: Rs. 175 *minus* Rs. 75 = Rs. 100

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*Not included in expenditure since the payment is in kind.

TABLE 113f. ESTIMATED COST OF CULTIVATION AND INCOME PER ACRE OF MONSOON CROP OF SEA ISLAND COTTON

Item of cultivation	Labour units			Cost (Rs.)
	Cattle (pairs)	Men	Women	
Total Cost:				
Preparatory cultivation:				
Ploughing and forming ridges	3	51	—	60·00
Sowing:				
Dibbling seeds and covering	—	—	12	6·00
After cultivation:				
Thinning, weeding, hoeing and earthing up	—	50	112	106·00
Manuring:				
Application of manure and covering	2	2	24	20·00
Plant protection:				
Application of fungicides and pesticides—five times	—	10	20	20·00
Harvesting:				
Picking *kapas* and cleaning	—	—	30	15·00
Post-harvest:				
Pulling out stalks	—	4	8	8·00
Cost of materials:		Rs.		
Cattle manure—three tons at Rs. 6 per ton		18·00		
Cost of 10 lb. of seed of 12 nP. per lb.		1·20		
Ammonium sulphate—two cwts.		34·00		
Super-phosphate—200 lb.		24·00		
Potassium sulphate—100 lb.		17·00		
Agrosan and folidol		32·00		
		126·20		126·20
		Total		361·20

Total Receipts:

	Rs.
Value of 750 lb. of seed cotton at Re. 1 per lb.	750·00

Net Profit: Rs. 750 *minus* Rs. 361·20=Rs. 388·80

For facility of comparison, labour requirements for different operations have been shown in units of cattle pairs, men and women. Furthermore, a uniform charge of Rs. 3 per day of eight hours for hiring one pair of bullocks and the daily wages of Re. 1 and Re. 0.50 per man and woman labourer, respectively, have been taken on the basis of cultivation costs. If labour wages and cotton prices ruling in any locality are different from those used in these estimates and if any additional expenditure is incurred on manuring or irrigation in special circumstances, due allowance will have to be made to arrive at correct costs and profits. Adjustments are also necessary on account of land rent and the proportionate annual allowance for the cost of permanent improvements, if any.

SEED MULTIPLICATION AND DISTRIBUTION

For the maintenance of high yield and superior spinning performance of improved varieties, the production and supply of their pure seed for large-scale cultivation is necessary. This is particularly so because most of the cotton growers in Madras State, like their *confrere* in the rest of India, sell their produce as *kapas* (unginned cotton) and buy sowing seed from ginning establishments or village merchants. This market seed not only contains an appreciable mixture of off-types but is also often of low viability due to faulty storage and handling. To meet the requirements of pure seed, the State Department of Agriculture operates several seed multiplication and distribution schemes with financial assistance from the Indian Central Cotton Committee. The schemes are worked by the Department, either directly or with the help of the local co-operative societies. Botanically pure seed of well tested improved varieties is first multiplied in a 'nucleus plot' at a research station and special arrangements are made for the extensive self-pollination of plants. The pure 'selfed seed' thus obtained is supplied to influencial and trustworthy farmers for multiplication in the Second Stage. The holdings of these farmers constitute the 'inner seed farms' and the growers execute seed farm indentures by which they undertake to do the following:

1. Use only departmental seed for sowing and gap-filling.
2. Permit the Agriculture Department to inspect the crop in the field and remove all off-type plants.
3. Keep the produce separate and arrange for its ginning under official supervision in an approved ginnery.
4. Sell back the seed after proper cleaning and drying to the Agricultural Department at a small agreed premium.

The seed procured from such 'inner seed farms' is sold for further multiplication to other groups of growers, constituting the 'outer seed farms'. The crop of this Third Stage is subjected to the same process of field inspection, controlled ginning and seed procurement. The seeds from this stage are stocked by the Department and sold outright to other cotton growers as certified seed. The Agricultural Department also helps the 'seed farm' *ryots* to sell their pure lint at a good price. In some areas, special co-operative societies have been organised and entrusted with the production and sale of seeds of the Second and Third Stages. The societies are provided with technical staff and given a substantial subsidy in the early stages.

The following special seed schemes have functioned in the State from time to time:

1. Co.2 seed distribution scheme for 1,00,000 acres in Coimbatore and Salem districts; the scheme was later converted into a combined scheme for Cambodia 2 and Karunganni 5.

2. Co.3 seed distribution scheme in Salem district; the scheme was terminated in 1946 when the variety was replaced by M.C.U.1.
3. Karunganni cotton seed distribution scheme for 3,50,000 acres in Tirunelveli, Ramanathapuram and Madurai districts; it was later combined with the scheme for M.C.U.1 and M.C.U.2 varieties.
4. Karunganni 5 seed multiplication scheme for 1,42,000 acres in Coimbatore district.
5. Cambodia 4 (Madras Cambodia Uganda 1) seed distribution and marketing scheme for summer planted area in southern districts; it is now operated as a combined scheme for M.C.U.1 and Karunganni 2 varieties.
6. Scheme for multiplication and distribution of seed of Madras Cambodis Uganda 1 cotton for 2,00,000 acres of winter cropped area in Coimbatore, Madurai, Tiruchirapalli and Salem districts.

The varieties under the schemes were changed from time to time as new and better strains were evolved by crop improvement work. The quantities of pure seed of improved varieties distributed by the Agriculture Department in the State during 1955-56 and the total areas covered by them were as follows:

Variety	Quantity of seeds distributed (lb.)	Total area covered inclusive of natural spread (acres)
Cambodia 2	327,531	56,983
M.C.U.1	15,96,746	1,37,053
M.C.U.2	6,93,113	46,645
Karunganni 2	7,98,956	1,65,159
Karunganni 5	17,12,235	1,98,388
P. 216F	49,933	7,376

In a further effort to maintain the purity of improved varieties in extensive cultivation, the State Government has enacted a Cotton Control Act whereby, the farmers are required compulsorily to grow only officially approved varieties in zones specified for them.

UTILISATION OF COTTON SEED AND ITS PRODUCTS

The production of cotton seed in the State is estimated at 1,00,000 tons per annum. The entire quantity is utilised as cattle feed after meeting the requirements for sowing. However, the State is deficit in regard to the seed needed for cattle, and the shortage is met partly by an annual import of about 16,000 tons of cotton seed from the neighbouring States, mainly former Hyderabad, and partly by the use of groundnut, *til* and coconut cakes.

There are no oil mills in the State for extraction of cotton seed oil.

Cultivators believe that fuzzy-seeded American cottons are not as nutritive as the Indian cottons. The figures of analysis given in Table 114, together with the results of nutrition experiments conducted in the Punjab, belie this impression.

TABLE 114. COMPOSITION OF SEED OF AMERICAN AND INDIAN COTTON VARIETIES

Components	American varieties		Indian varieties	
	Cambodia	Madras Uganda 1	Karun-ganni 2	Karun-ganni 5
Moisture	7·45	7·31	8·00	8·10
Protein	18·37	20·13	17·19	16·94
Ether extract	22·96	23·00	17·14	17·00

COTTON LEGISLATION

In order to check the malpractices prevalent in the trade and some processing factories, and to ensure a regular supply of good quality cotton to consuming mills, the State Government enacted specific legislations from time to time. These enactments were mainly aimed at: (*i*) the prevention of deliberate mixing of inferior cotton, foreign matter, etc., with good quality produce in the process of ginning and pressing; (*ii*) the prohibition of cultivation of low grade cotton varieties in certain zones; and (*iii*) the control of the damage caused by injurious insects.

The first legislative action taken in Madras State, was the application of the Provisions of the Madras Agricultural Pests and Diseases Act, 1919, for the stem weevil and pink bollworm pests of cotton. Subsequent measures imposed restrictions on the cultivation of low grade cottons, regulated the operation of markets, controlled the transportation of raw cotton by rail, road and sea and licensed the working of ginning and pressing factories. Their objects and their main provisions are summarised below:

MADRAS AGRICULTURAL PESTS AND DISEASES ACT OF 1919

The Act, as subsequently amended, was made applicable for two insect pests, viz., pink bollworm (*Platyedra gossypiella*) and stem weevil (*Pempherulus affinis*), attacking Cambodia and Pachanadan varieties of cotton. The Act required that cotton crops in the notified districts of Coimbatore, Salem, Tiruchirapalli and Madurai should be pulled out and allowed to wither before August 1, of every year. The object was the removal of host cotton plants to starve the insects during the off-season and thus reduce their potential population available for attacking the next crop. In actual working, however, the measure was never strictly enforced, frequent exemptions being granted to individual growers. Later, the Act itself was amended extending the last date for removing the cotton plants to the end of August, thereby making the 'no-cotton' period of one full month between two successive crops completely inoperative. Later, research on the control of stem weevil showed that a large number of other plants occurring as weeds in the cotton belt served as alternate hosts; that *desi* cottons, which were exempted from the provisions of the Act, were equally susceptible; that the longevity of the adult weevils was greater than the 'no-cotton' interval of one month originally prescribed. The remedy, therefore, appeared to lie in evolving varieties resistant to stem weevil and in controlling the pink bollworm in the fruiting stage and in *kapas* storage. The work of producing resistant varieties has been partly achieved by the hybridisation of annual American cottons with the Moco variety, while the work on the control of pink bollworm has been intensified by the greater use of pesticides on the crop, and the fumigation of seed with methyl bromide.

COTTON TRANSPORT ACT (ACT III OF 1923)

This Act restricts and controls the road, rail and river transport of ginned and unginned cotton, cotton waste, cotton seed and every kind of unmanufactured cotton in certain protected zones in order to maintain the quality and reputation of cotton grown in them. The two protected zones in Madras State are: (*i*) Cambodia area comprising the districts of Chingleput, South Arcot, North Arcot, Salem, Coimbatore, Tiruchirapalli and Tanjore; and (*ii*) parts of Madurai and Ramanathapuram districts lying to the west and south of Kothagudi river and the east and south of Vaigai river, bounded by the Periyar Channel up to Melur and thence by the Melur-Sivaganga-Manamadura road.

GINNING AND PRESSING FACTORIES ACT (ACT XXII OF 1925)

The Act prescribes the use of standardised weights and measures and requires every owner of a ginning or pressing factory to maintain a register in the prescribed form showing the dates and the names of persons for whom ginning and pressing are done, together with the details of quantity. The owners of pressing factories have to mark the bales in the prescribed manner and submit weekly returns for the varieties and quantities ginned and pressed. The Act also penalises deliberate malpractices like mixing of varieties, watering of cotton and adulteration with seed, leaf or foreign matter. Apart from the regulation of the working of ginning and pressing factories, the Act ensures greater accuracy in the compilation of statistical data relating to cotton production.

MADRAS COMMERCIAL CROPS MARKETS ACT, 1933

The Act provides for the better regulation of buying and selling of agricultural produce and for the establishment of markets for this purpose. The

Act has been applied to cotton in the districts of Coimbatore, Ramanathapuram and Tirunelveli. The market committees consisting of representatives of the growers and the traders have power to enact bye-laws to regulate market prices, to fix tare, commission, trade allowance, etc., and to check scales and weights.

MADRAS COTTON CONTROL ACT, 1932

The Act (Act VII of 1932) had for its object the prohibition of cultivation and the prevention of mixing, trade in and possession of the low grade cotton named Pulichai (*G. arboreum* race *bengalense*) either in a pure or mixed form. This Act was enforced in the districts of Madurai, Ramanathapuram, Tirunelveli and Coimbatore and the officers of the Madras Agricultural Department were empowered to seize Pulichai cotton from any premises where it was grown or stored for mixing, and to prosecute the offenders by preferring a complaint to the district magistrate after obtaining the sanction of the Director of Agriculture. On account of intensive propaganda and prosecutions launched against offenders, the low grade cotton has been almost eradicated. This Act was repealed in 1952 after a more comprehensive one was passed. The new Act aims at the preservation of the purity of improved varieties of cotton grown in the State, by prescribing the cultivation of specified varieties to the exclusion of others; by prohibiting the mixing of specified variety of cotton with any other variety; and by preventing the possession and use of or trade in named varieties of cotton in the notified areas. This Act is called the Madras Cotton Control Act of 1952 (Act XV of 1952).

The Act has not been implemented as yet and the draft notifications and schedules are under consideration of the Government.

MADRAS COTTON TRADE CENSUS ACT

The Act requires every trader and every owner of cotton as also every ginning and pressing factory to declare stocks of raw cotton held on January 31 and August 31, of every year. Heavy penalties are prescribed for non-compliance. The object is to collect reliable data relating to stocks of Indian cotton held by the traders on the specified dates.

RESTRICTIONS IMPOSED ON COTTON CULTIVATION DURING THE SECOND WORLD WAR

In order to increase the production of food crops during the Second World War, the Madras Government enforced restrictions on raising a crop of cotton from any irrigation source, private or public. This enactment, under the Defence of India Rules, led to a large curtailment of cotton area, until it was repealed.

COTTON PRICE CONTOL

In order to combat inflation and to check the soaring prices of manufactured cloth, the Government of India's policy of price control was applied to Madras cottons also. Later, some of the superior long staple cottons, like M.C.U.1 and M.C.U.2, were exempted from price control. At the same time, the State Government initiated the Superior Cotton Certification Scheme as a complementary measure to ensure the maintenance of the purity and the fibre qualities of cottons of a staple length of one inch and above. The scheme provides for the compulsory purchase of sowing seeds from departmental depots, registration of area, roguing of the crop, ginning of *kapas* in licensed factories, registration of produce and pressing under supervision. Certificates are issued by the staff of the Agricultural Department for those lots which conform to these provisions and possess a minimum staple length of full one inch. The scheme has not only benefited the grower and the consumer, but has also encouraged increased production of quality cottons in the State.

CHAPTER IV

CENTRAL *HERBACEUM-ARBOREUM-HIRSUTUM* REGION

INTRODUCTION

Constituent States. The Central *herbaceum-arboreum-hirsutum* Region comprises the new Andhra Pradesh and the re-organised Mysore State. The territories forming the two States as constituted under the States Re-organisation Act of 1956 are specified below :

Re-organised States		Territories included
Andhra Pradesh	—	Andhra *plus* the following portions of Hyderabad : Hyderabad, Medak, Nizamabad, Karimnagar, Warangal, Khammam, Nalgonda and Mahbubnagar districts; Alampur and Gadwal *talukas* of Raichur district ; Kodangal and Tandur *talukas* of Gulbarga district; Zahirabad *taluka* (except Nirna circle), Nyalkal circle of Bidar *taluka* and Narayankhed *taluka* of Bidar district, Bichkonda and Jukkal circles of Deglur *taluka* of Nanded district; Mudhol *taluka* of Nanded district and Adilabad district (except Islapur circle of Boath *taluka*, Kinwat and Rajura *talukas*).
Mysore	—	Mysore State *plus* Belgaum (except Chandgad *taluka*), Bijapur, Dharwar and Kanara districts of Bombay ; Gulbarga district (except Kodangal and Tandur *talukas*), Raichur district (except Alampur and Gadwal *talukas*), Bidar district (except Ahmedpur, Nilanga and Udgir *talukas*), Zahirabad *taluka* (excluding Nirna circle, Nyalkal circle of Bidar *taluka* and Narayankhed *taluka*) of Hyderabad State; South Kanara district (except Kasaragod *taluka* and Amindivi Islands); Kollegal *taluka* of Coimbatore district of Madras State; and Coorg State.

Area and Boundaries. The two States combined cover a total area of nearly 1,80,000 square miles (Andhra Pradesh 1,05,677 square miles and Mysore State 74,093 square miles), situated between 11° 38' and 19° 53' N. and 74° 10' and 83° 20' E. The region is bounded by Bombay, Madhya

Pradesh and Orissa on the north, by the Bay of Bengal on the east, by Madras and Kerala States on the south and by Arabian Sea on the west.

Physical Aspects. Excepting its coastal districts, Andhra Pradesh forms part of the Deccan Plateau. It is traversed by the relatively low broken hills of the Eastern Ghats, which run in a north-south direction within a few miles of the Bay of Bengal coast. Ranges of low hills also exist in Adilabad district in the north. The surface slopes markedly from north to south and south-east· The average altitude above sea level falls from about 2,500 feet at some places in Adilabad district to 1,700 feet at Hyderabad; to between 800 and 900 feet at Khammam and still lower further to the south and near the Eastern Ghats. Beyond this hill range, it rapidly tapers off eastward to the sea shore. Andhra Pradesh is composed of three natural divisions : (*i*) undulating, hilly, plateau tract of Telengana in the north; (*ii*) level, black soil, arid plains of Rayalaseema in the south; and (*iii*) relatively low lying coastal Andhra extending as a narrow belt along the sea face of the Eastern Ghats.

In Mysore State, Raichur Division and the northern portion of Dharwar Division form part of the Deccan Plateau. This tract is relatively flat, with a gentle slope from north to south and south-east, the average altitude declining from about 1,500 feet at Bidar to 1,200 feet at Raichur and still lower at Bellary. The remainder of the State forms a huge plateau, sloping from west to east, with practically all rivers flowing eastwards. It is higly undulating and has a general elevation of about 2,000 feet above sea level, descending in the west to the sea coast below the Western Ghats and terminating at the foot of the Nilgiri Hills in the south. The Western Ghats which traverse the State in the north-south direction within a few miles of the Arabian Sea coast, attain a height of 4,000 to 5,000 feet at some places. Many spurs of the Western Ghats extend into the plateau in a west-east or a north-west, south-east direction. The Bangalore tract forms a table land with an altitude of about 3,000 feet, broken by numerous rugged ridges. Like Andhra Pradesh, the State of Mysore also is divided into three natural divisions: (*i*) hilly tract, called *Malnad*, in the west, bordering the Western Ghats; (*ii*) more open plains region, called *Maidan*, in the centre and east; and (*iii*) extensive black soil tract covering large parts of Bellary, Raichur and Gulbarga districts in the north.

Geological Features. Geologically, almost the whole of Telengana and the Mysore Plateau south of the Krishna river are composed primarily of schists and gneisses. They are characterised by rugged, rolling country, with isolated bare hills, extensively covered with forest or jungle when not cultivated. The valley of the Krishna, extending: (*i*) from its junction with Ghataprabha westwards up to the Western Ghats; and (*ii*) from its junction with Tungabhadra to the Eastern Ghats, whence it debouches into the East Coast plain, has the Cuddapah rocks, which are an ancient series of sedimentary strata derived from the old archaean rocks and consist primarily of shales, slates and limestones. The Cuddapahs extend southwards as far as Tirupathi, 30 miles north-west of Madras.

In the valley of the Godavari on the plateau, extending as far as the junction of the Wardha and Penganga rivers, is the Gondwana series. They are fresh water sandstone deposits producing gravelly, infertile soils. It is the main coal-bearing system of the region.

The territory comprising northern Dharwar, Bellary, Raichur, Bijapur and the western parts of Gulbarga, Bidar and Adilabad districts forms part of the 'Deccan trap' which consists of vast horizontal sheets of basaltic rocks of volcanic origin. The trap extends as far north as the Penganga river and then runs along its south bank almost to its junction with Wardha. The *regur* or black soil is particularly associated with these rocks. The trap country is mostly level, broken here and there by flat topped, steep sided, often terraced hills, which are generally bare of all vegetation except coarse grass. The general aspect of this tract is in marked contrast to the rolling, rugged, wooded country of the metamorphic region.

Coastal Andhra has several outcrops of upper Gondwanas, the principal one of which is located near Rajamundri on the Godavari delta. It consists largely of sandstones and shales. Rocks of Cuddalore series also occur in some places. They are made up of loose textured sandstone, often ferruginous, argillaceaus and gritty. The rest of the coastal belt is largely alluvial.

River Systems. Andhra Pradesh is served by the two large rivers, Godavari and Krishna, both of which originate in Bombay State and after flowing in an easterly or south-easterly direction, empty into the Bay of Bengal. Waters in the lower reaches of both the rivers have been harnessed for growing irrigated food and garden crops on an area of about two million acres. Before entering Andhra Pradesh, the Krishna with its tributaries Bhima (from the north) and Tungabhadra (from the south) passes through Gulbarga, Raichur, Dharwar and Bellary districts of Mysore State. A large irrigation dam has been constructed across the Tungabhadra. With the completion of the associated net-work of canals, the project is expected to irrigate about eight hundred thousand acres in Mysore and about one hundred and fifty thousand acres in Andhra Pradesh. The construction of the Bhadra Project in the Shimoga district of Mysore and of another project (the Nagarjunasagar) to harness the waters of the Krishna in Andhra Pradesh has been taken up recently. When completed, the gigantic Nagarjunasagar alone will irrigate about 2.3 million acres. About 10 per cent. of the area eventually irrigated by the Tungabhadra and Nagarjunasagar Projects is likely to be devoted to the cultivation of high quality American cottons. The southern part of Mysore is traversed by the Kaveri river. Near the city of Mysore, this river has been harnessed by the Krishnaraja Sagar dam. In addition to these large river systems, both the States possess a large number of streams, most of which are of a seasonal character. They not only drain the rain waters but also form part of many minor irrigation schemes.

Means of Communication. A net-work of broad and meter gauge lines of the Central, Southern and South-Eastern Railways covers the region in all directions. It not only connects the main cotton-growing areas with the internal markets and processing centres but also links the latter with the manufacturing cities of Bangalore, Coimbatore, Hubli, Hyderabad and Warangal as well as the port towns of Madras, Masulipatam, Kakinada and Visakhapatnam on the East Coast, and Bombay on the West Coast. The road communications are also equally well developed. The road communications are being further expanded rapidly under the country's quinquennial development plans. An attempt is under way as part of the Community Development Programme to link every village with the motorable trunk or feeder roads during the next three or four years. Some parts of coastal Andhra and Rayalaseema are connected with Madras by a navigable canal also. This water communication constitutes a valuable adjunction to the rail, motor and cart transport serving the area.

AREA AND PRODUCTION

Cultivated Area and Principal Crops. The area annually cultivated in this region as compared with the corresponding figures for the whole of India, during the seven years ending 1955-56, was as shown in Table 115.

TABLE 115. NET AREA SOWN UNDER COTTON IN THE REGION COMPARED TO THE ALL-INDIA TOTAL

State	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	Average
			(million acres)					
				Actual				
Andhra Pradesh	23·89	24·23	25·33	25.43	27·27	29·17	28·83	21·31
Mysore	22·98	23·04	23·75	23·65	24·38	22·94	23·28	23·43
All-India	283·22	293·43	295·04	304·67	313·06	325·87	325·77	305·87
			Per cent. of all-India total					
Andhra Pradesh	8·4	8·2	8·6	8·3	8·7	9·0	8·8	8·6
Mysore	8·1	7·8	8·0	7·8	7·8	7·0	7·1	7·6

Thus out of the average annual cropped area of 305.87 million acres for the whole of India, Andhra Pradesh accounted for 26.31 million acres (8.6 per cent.) and Mysore State for 23.43 million acres (7.6 per cent.). A large bulk of the cultivated area of the region consists of single crop land. In the case of irrigated paddy tract and the garden soils only, two crops are taken in a year on the same land.

The average annual area of different crops in the two States, during the period 1949-50 to 1955-56, was as shown in Table 116.

TABLE 116. AVERAGE ANNUAL AREA UNDER PRINCIPAL CROPS—1949-50 TO 1955-56

Crop	Average annual area (thousand acres)		Percentage of total area under all crops	
	Andhra Pradesh	Mysore	Andhra Pradesh	Mysore
Cereals:				
Rice	5,877	2,041		
Jowar	5,968	6,164		
Bajra	1,547	1,124		
Maize	418	27		
Ragi	757	1,957		
Small millets	2,623	1,188		
Wheat	54	717		
Barley	8	8		
Total Cereals	17,252	13,226	61·9	61·7
Pulses:				
Gram	307	409		
Tur	488	581		
Other pulses	2,943	1,846		
Total Pulses	3,738	2,836	13·4	13·2
Oilseeds:				
Groundnut	2,851	1,881		
Castor	929	127		
Sesamum	794	229		
Linseed	84	141		
Rape and Mustard	3	12		
Total Oilseeds	4,661	2,390	16·7	11·1
Fibre crops:				
Cotton	1,237	2,282		
Mesta	106	51		
Total Fibre Crops	1,343	2,333	4·8	10·9
Miscellaneous:				
Sugarcane	164	106		
Chillies	382	271		
Tobacco	326	96		
Black pepper	—	16		
Ginger	1	2		
Potato	1	10		
Tea	—	9		
Coffee	—	158		
Total Miscellaneous Crops	874	668	3·2	3·1
Total All Crops	27,868	21,453	100·0	100·0

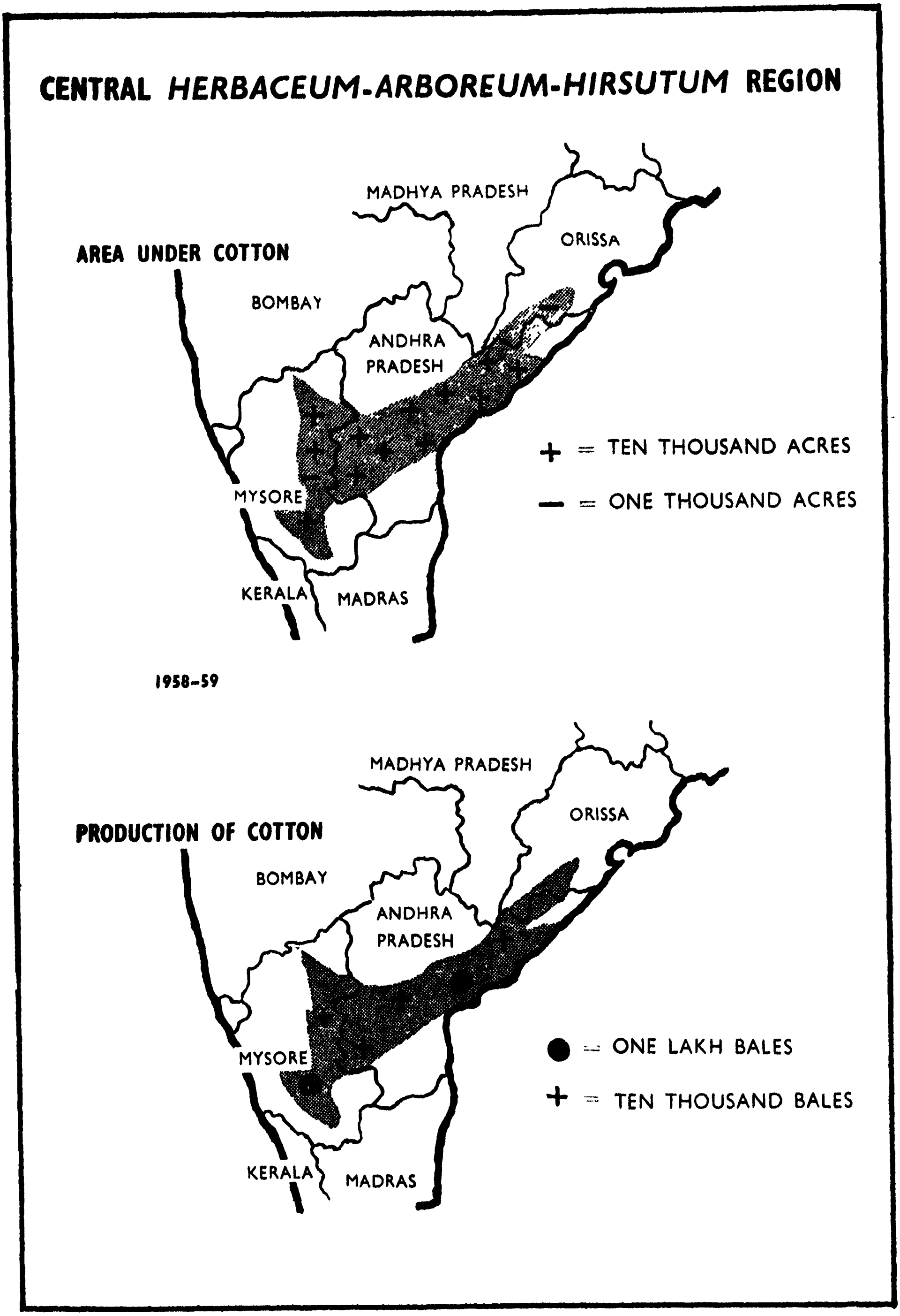


Fig. 24. Intensity of Area and Production of Cotton in the Central *herbaceum-arboreum-hirsutum* Region

The area and production of cotton in the region is depicted in Figures 24 and 25.

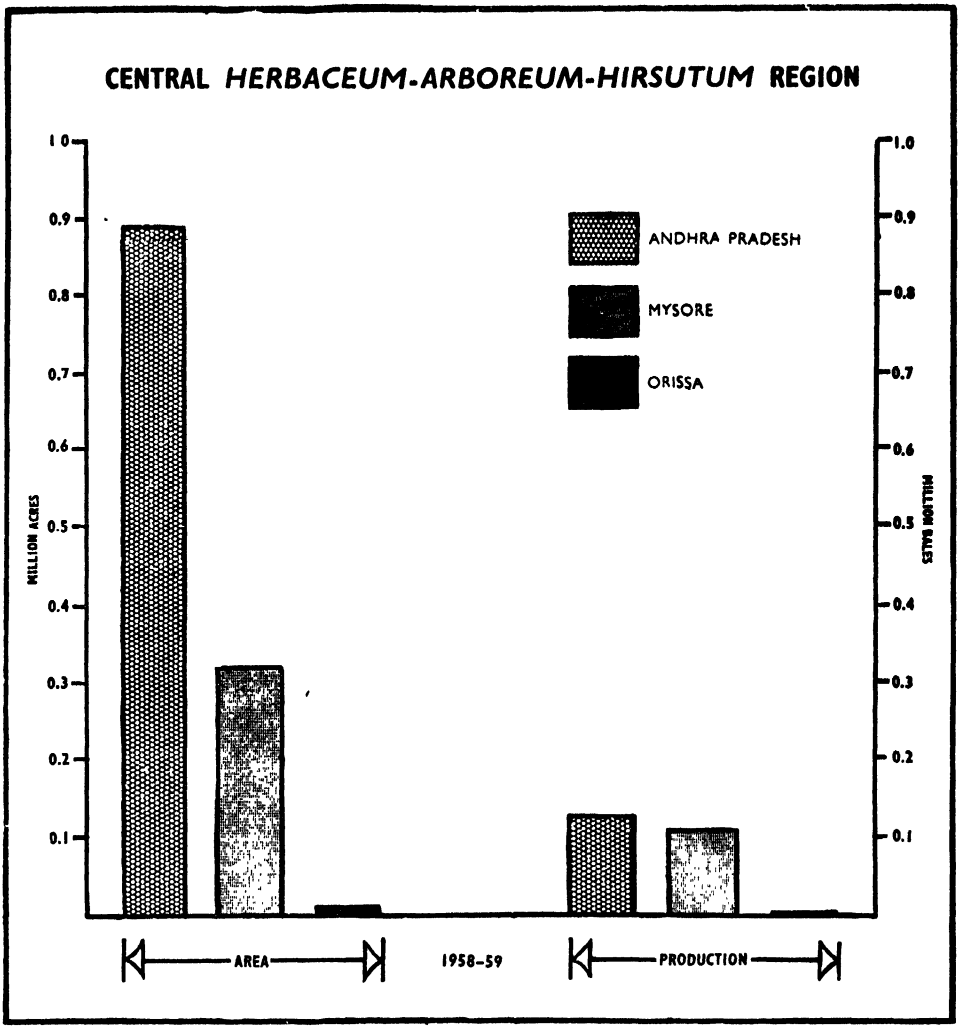


Fig. 25. Area and Production of Cotton in Different States of the Central *herbaceum-arboreum-hirsutum* Region

The food crops (cereals and pulses) cover nearly 75 per cent. of the annual cropped area of each State. The oilseeds account for another 16.7 per cent. in Andhra Pradesh and 11.1 per cent. in Mysore. The area under fibre crops (cotton and mesta) represents 4.8 per cent. of the total area under all crops in Andhra and 10.9 per cent. in Mysore. All the other crops (including sugarcane, chillies, tobacco and coffee) occupy only three per cent. of the total crop area.

Jowar (Sorghum), rice, *bajra* (Bullrush millet), *ragi* (*Eleusine corocana*), small millets and pulses of different kinds are the principal food crops of the region. Maize also occupies a fairly large area in Andhra Pradesh, and wheat in Mysore.

Oilseeds, cotton, sugarcane, chillies and tobacco are the important cash crops of both the States. Amongst oilseeds, groundnut occupies the foremost place in both the States; castor and sesamum are of special importance to Andhra Pradesh. In Coorg and the adjoining upland districts of Mysore, coffee is another important cash crop.

Area and Production of Cotton. The cotton crop in Mysore State is of much greater economic importance than in Andhra Pradesh. It occupies about 10.6 per cent. of the annual crop area in the former and only 4.4 per cent. in the latter. Table 117 shows the annual area of cotton in each of the two States as compared with the cotton area in the whole of India and Table 118 gives the corresponding figures of the total annual cotton production.

TABLE 117. ANNUAL AREA UNDER COTTON

	Area (thousand acres)							Annual average
	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	
Andhra Pradesh	1,016	1,413	1,538	1,084	1,198	1,218	1,195	1,237
Mysore	1,868	2,321	2,299	1,958	2,283	2,449	2,798	2,282
All-India .	12,173	14,536	16,201	15,713	17,265	18,684	20,230	16,400

TABLE 118. ANNUAL PRODUCTION OF COTTON

	Production of cotton lint (thousand bales of 392 lb.)							Annual average
	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	
Andhra Pradesh	154	171	221	135	118	158	140	157
Mysore	296	305	315	282	378	353	411	331
All-India	2,628	2,910	3,133	3,194	3,944	4,227	3,998	3,433

Staple-wise area and production of cotton during 1955-56 for this region have been shown in Figure 26.

On the basis of the seven years from 1949-50 to 1955-56, the annual cotton area and production of Andhra Pradesh were 1.24 million acres and

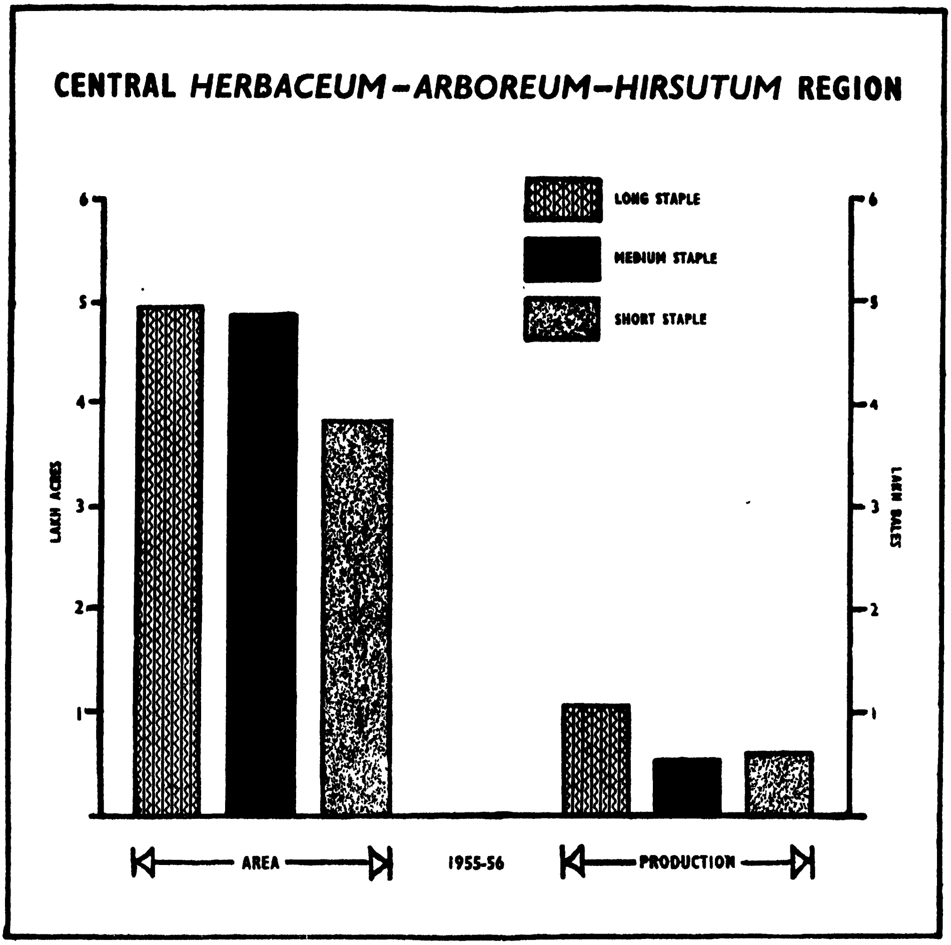


Fig. 26. Staple-wise Area and Production of Cotton in the Central *herbaceum-arboreum-hirsutum* Region—1955-56

157 thousand bales, forming 7.54 and 4.6 per cent., respectively, of the area and production of cotton in the whole of India. Similarly, the average annual area and production of cotton in Mysore for the same period were 2.28 million acres and 331 thousand bales, representing 14 per cent. of the total cotton area and 9.6 per cent. of the total cotton production, respectively, in the whole of India. · It may be noted that the annual output of cotton in both the States is much less than what may be expected on the basis of the annual acreage. This is due to the lower yield per acre obtained in this region as compared with the average yield per unit area for the country as a whole. Figures of yield given in Table 119 bear out this fact.

TABLE 119. AVERAGE YIELD OF COTTON LINT (LB. PER ACRE)

	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56
Andhra Pradesh	59	47	57	49	39	51	46
Mysore	62	52	54	56	65	57	58
All-India	85	78	76	80	90	84	77

Area and production of cotton during the First and Second Five-Year Plan periods is depicted in Figure 27.

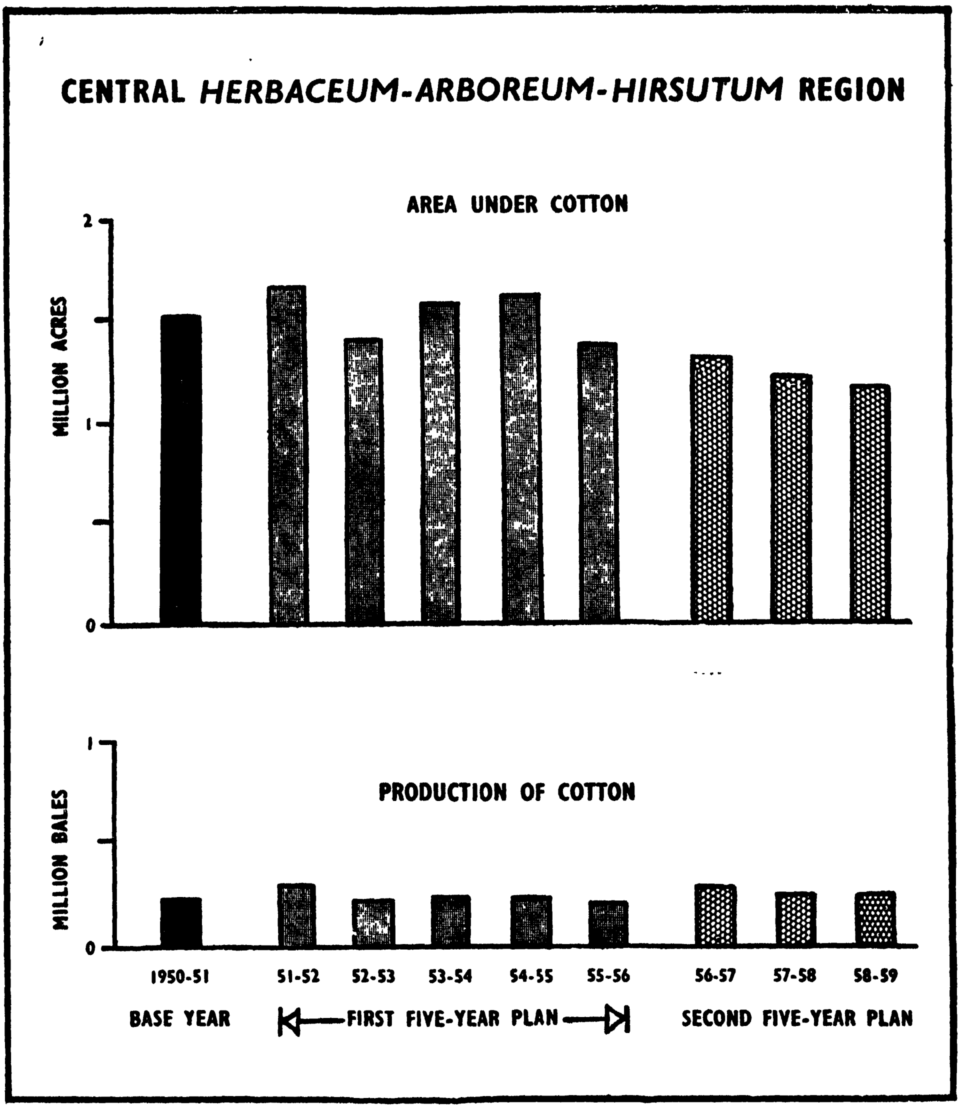


Fig. 27. Area and Production of Cotton During the First and Second Five-Year Plan Periods in the Central *herbaceum-arboreum-hirsutum* Region

Work for the extension of cotton cultivation to newly reclaimed lands and for the introduction of H.14 cotton (P.216F) as a second crop after paddy in single crop wet lands in the coastal districts of Andhra Pradesh is in progress as part of the Second Five-Year Plan. Taken together with the extension of irrigated cultivation under the Tungabhadra and other projects, this is expected to increase the cotton area and production of Andhra Pradesh considerably in the near future.

Practically the entire cotton crop of the region is grown unirrigated. The annual area under irrigated cotton in the quinquennium ending 1953-54 in the two component States was as shown in Table 120.

TABLE 120. ANNUAL AREA UNDER IRRIGATED COTTON

	Area under irrigated cotton (thousand acres)				
	1949-50	1950-51	1951-52	1952-53	1953-54
Andhra Pradesh	4	1	3	3	2
Mysore	27	18	23	20	24
All-India	993	1,148	1,422	1,282	1,462

It may be mentioned in passing that the total annual area of all irrigated crops during the same period varied from 5.7 to 6.6 million acres in Andhra Pradesh and from 1.5 to 1.6 million acres in Mysore, representing 22 to 24 per cent. and 6 to 7 per cent., respectively, of the annual crop area of the State concerned. Food crops (particularly rice), sugarcane, vegetables, fruits and chillies are the principal crops grown under irrigation in each State. The growing of unirrigated cotton under a highly precarious rainfall is one of the reasons of the very low crop yields obtained in this region. As already mentioned, several irrigation projects are under construction in both the States. It is estimated that they will eventually irrigate an additional area of 3.5 million acres in Andhra Pradesh and nearly 0.5 million acres in Mysore, of which 0.3 and 0.14 million acres, respectively, will be under irrigated cotton in the two tracts.

VARIETIES GROWN

The principal varieties grown in Andhra Pradesh are : Hyderabad Oomras; Hyderabad Gaorani; Mungari; Westerns; Northerns; Cocanadas; Chinnapathi; and Cambodia.

Hyderabad Oomras. This variety is grown in the Telengana districts of Nizamabad, Karimnagar, Adilabad, Warangal, Medak and some parts of Mahbubnagar. In Adilabad district, it is known locally as 'Havri' or 'Katel'. In the field, this variety consists of a varying mixture of plants belonging to the *bengalensis* and *indica* forms of *Gossypium arboreum* L. var. *neglectum* Watt., the former (i.e., *bengalensis*) being the predominant type. In Nizamabad district, the crop is made up wholly of *G. herbaceum* L. var. *frutescence.* Oomras is a relatively high yielding type, producing 300 to 350 lb. of *kapas* (unginned cotton) per acre. The cotton is rather coarse and white to creamy-white in colour. It has a ginning outturn of 33 to 35 per cent. and a spinning capacity of 8's to 12's warp counts. The ginning outturn of the Nizamabad produce is 27 to 28 per cent. and it is fit for spinning 16's to 20's warp counts. The annual area under Hyderabad Oomras is about 250 thousand acres and lint production about 60 thousand bales of 392 lb. each. However, the cultivation of this variety is on the wane. The inferior types are being rapidly replaced by improved varieties.

Hyderabad Gaorani. This variety is also known as 'Bani' cotton and depending on the place of origin, it is given the distinctive names of Bhainsa Bani and Nirmal Bani. It is grown in Madhol and Boath *talukas* of Adilabad district. Botanically it is *G. arboreum* L. var. *neglectum* Watt. forma *indica.* Practically the entire crop is now composed of improved varieties—Gaorani 6 and 12 (Plate XIII). Grown from improved seed, it has an average yield of about 300 lb. of *kapas* per acre, a ginning percentage of 30 to 32, staple length of 7/8" to 15/16" and spinning capacity of 24's to 28's warp counts. The annual area under this variety is about 120 thousand acres, and the production about 25 thousand bales.

In the Ghat (highland) areas of Adilabad district, having a relatively higher and more assured rainfall, a newly produced variety of *G. hirsutum* was introduced a few years ago under the name Parbhani-American. This variety is resistant to jassid and takes somewhat longer time to mature. Its average yield is 250 to 300 lb. of seed cotton per acre. This cotton has a ginning outturn of 32 to 34 per cent., a staple length of 7/8" and spinning capacity of 20's to 24's warp counts. It is dull or creamy-white in colour and soft and silky in feel. It is now grown on an area of nearly 100 thousand acres annually, producing about 25 to 30 thousand bales.

Mungari. The cotton owes its name to its being sown in the early or *mungari* season (June-July). In botanical composition, it is similar to Hyderabad Oomras but has a much higher content of forma *bengalensis.* It was introduced in this tract in or about 1910. Finding rapid favour with the cultivators on account of its good yield and high ginning outturn, it is now grown on about 100 thousand acres annually on red and light black soils in the districts of Anantapur, Kurnool and Cuddapah, producing 20 to 25 thousand bales. It has a ginning outturn of 33 per cent., staple length of 1/2" to 3/4", and has white, coarse staple, fit for spinning 8's to 10's warp counts. Its average yield is 300 to 350 lb. of *kapas* per acre.

Westerns. This variety is locally known as 'Hingari' from the late (August-September) or *hingari* season in which the crop is sown. It is also called 'Jowari'. Botanically, it is *G. herbaceum* L. var. *frutescence.* It is grown on black soils in Alur, Adoni and Pattikonda *talukas* of Kurnool district, Gooty and Tadapatri *talukas* of Anantapur district and Proddatur and Jammalamadugu *talukas* of Cuddapah district. In comparison with Mungari, it is a shy bearer, producing on the average 200 to 250 lb. of *kapas* per acre and has a ginning outturn of 27-28 per cent. The lint of this variety is soft bodied, slightly creamy in colour, 7/8" in staple length and fit for spinning 24's warp counts. It is cultivated annually on 300 to 400 thousand acres, and its yearly production is about 50 thousand bales. Much of the current area is planted with improved varieties.

Northerns. This variety is grown in Kurnool district (particularly the Nandyal valley) and some parts of Anantapur and Cuddapah districts. It is a mixture of *G. arboreum* L. var. *neglectum* Watt. forma indica and *G. herbaceum* L. var. *frutescence*. *Herbaceum* is generally the predominating component on black soils and *indica* on red soils. The cotton produced on black soils is creamy-white and is called White Northerns or Tellapathi, whereas that grown on red soils is red tinted and is termed Red Northerns or Yerrapathi. The average yield is about 250 to 300 lb. of *kapas* per acre and the ginning outturn is 24 to 25 per cent. The staple length is 7/8" to 15/16" and the lint is fit for 20's to 24's warp counts. Some samples of an improved variety of White Northerns can be spun up to 32's warp counts. The annual area is about 120 thousand acres and production nearly 25 thousand bales, of which about 15 thousand are of White Northerns.

Cocanadas. This cotton derives its name from the port of Coconada from which is used to be shipped to foreign countries. It is cultivated in Guntur, Nellore, Krishna, Khammam and Nalgonda districts, Cumbum and Markapur *talukas* of Kurnool district and some parts of East Godavari district. The produce of Kurnool district forms part of Red Northerns. Cocanadas is the only coloured cotton grown in India on a commercial scale. It has a red, dark brown, or drab coloured lint, possessing a staple length of 5/8" to 3/4". Its ginning outturn is 23 to 26 per cent. The raw cotton is harsh to fairly fine in feel and is suitable for spinning 16's to 20's warp counts. Its annual area is about 80 thousand acres and the production about 15 thousand bales. About 30 per cent. of the annual output is lighter in colour. The light coloured cotton is produced in humid coastal localities, whereas deeper coloured produce is grown in more inland places. Improved types are gradually taking the place of the original mixed variety.

Chinnapathi. This is a white-linted, early cotton, grown on a relatively small area in Visakhapatnam and Srikakulam districts. Botanically, it is akin to *G. arboreum* L. var. *neglectum* Watt. Its average yield is 250 to 300 lb. of *kapas* per acre and ginning outturn only 25 per cent. The annual area seldom exceeds five thousand acres. The cotton is coarse and short stapled; it is used almost wholly for hand-spinning.

Cambodia (Madras-American). This is a type of *G. hirsutum* grown to a small extent on red loam soils of Kurnool, Anantapur and Cuddapah districts. It is usually cultivated mixed with Asiatic varieties. Its average yield is 250 to 300 lb. of *kapas* per acre, and ginning outturn about 33 per cent. The raw cotton is creamy-white in colour, 7/8" in staple length, fine and silky in feel and fit for spinning 24's to 30's warp counts. In recent years, Bombay-American (Laxmi) has been gradually replacing Cambodia in some places.

The principal cotton varieties in cultivation in the re-organised Mysore State are : Mungari ; Kumpta and Westerns ; Dharwar-American ; and Mysore-American.

Mungari. This variety of Mysore is practically similar to the variety of the same name grown in Rayalaseema district of Andhra Pradesh. Locally it is also called Kotekal, Chinnapathi or Bokada. It is cultivated as an early sown crop on light types of soils in Gulbarga, Raichur, Bellary and the adjoining central districts of the State. The produce of some parts of Gulbarga district is somewhat finer, the crop containing a fairly large number of plants *of hirsutum* and *indica* varieties. In Raichur district, Mungari sometimes contains 10 to 20 per cent. of *herbaceum* plants. Mungari is exotic to Mysore State. It was introduced in this tract in the period from 1920 by cotton merchants, who imported the seed from Vidarbha markets, which now forms part of Bombay State. For reasons given already for the extension of its area in Andhra Pradesh, the cultivation of Mungari found rapid favour in some parts of Bellary and districts north of it. It is now grown on 125 to 150 thousand acres annually, producing about 25 to 30 thousand bales of lint. Excepting a small quantity grown in Gulbarga district, which is fit for spinning 16's to 20's warp counts, the produce of this variety is coarse and short stapled, capable of producing yarns of only 8's to 10's counts.

Kumpta and Westerns. These are also known as Javari or Hingari cottons. Botanically, both these varieties are *G. herbaceum* L. var. *frutescence.* They are grown as late sown crops on black soils of Gulbarga, Raichur, Bellary, Dharwar, Bijapur, Chitaldrug and Shimoga districts. The annual area under these varieties is about 800 thousand acres and production about 150 thousand bales of lint. The spinning qualities of these cottons are as good as, or somewhat better than, those of Westerns cotton grown elsewhere. These varieties are now grown very largely from improved seed.

Dharwar-American. This variety is also called Gadag Upland or Bombay-American, and is acclimatised and improved *G. hirsutum.* It is grown largely on the lateritic or light black soils of Belgaum, Bijapur, Dharwar, Raichur, Bellary and Chitaldrug districts. The average yield per acre is about 300 lb. of seed cotton and the ginning outturn is about 35 per cent. The fibre is white and silky, having a staple length of about one inch. It is fit for spinning 30's to 32's warp counts. The annual area under this cotton is about 1.2 million acres, producing 160 to 200 thousand bales.

Mysore-American. Locally called Doddahatti, this variety is closely akin to Dharwar-American (PlateXIV). It is grown as a rainfed crop on red soils of Mysore, Hassan, Chikmaglur, Shimoga and Chitaldrug districts and as an irrigated crop on Visveswariah Canal in Mandya district. The average yield is 250 to 300 lb. of *kapas* per acre for rainfed crop and 800 to 1,200 lb. for irrigated crop. The ginning percentage is 32 to 35 and the staple length varies from 7/8″ to 1″. The cotton is fine, silky and fit for spinning 26's to 30's warp counts. The annual area is 35 to 40 thousand acres, producing 12 to 15 thousand bales. An improved variety of hybrid origin now forms the bulk of the crop.

Besides the above-mentioned principal types, another variety called Nadam (*G. obtusifolium*) is cultivated on a small-scale in the black soils of Mysore district. It is not of much commercial importance.

CLIMATE

ANDHRA PRADESH

As mentioned already the State may be divided into three distinct parts, namely the coastal districts in the east, Telengana in the north and Rayalaseema in the south. Telengana and Rayalaseema constitute the main cotton tract.

There are three well-defined seasons: (*i*) moderately warm, rainy season, from June to October or the first half of November; (*ii*) cool, dry season, from November to February; and (*iii*) hot, dry season, from March to May. In South Telengana and Rayalaseema, day temperatures begin to rise early in February.

Temperature. The monthly mean maximum and minimum temperatures for six representative districts are given in Table 121. The mean maximum temperature in Telengana is at its lowest level (80° to 85° F.) in the months of November, December and January and rises to 90° F. in February and 95° to 98° F. in March. In April and May, it ranges between 101° and 107° F. With the commencement of monsoon rains in June, the maximum temperature falls again to the level of 95° to 97° F. During the rainy months of July, August and September, it hovers about 85° F. The month of October is somewhat hotter. Thereafter, the season is cool and dry. The mean maximum temperature in Rayalaseema though following the same general pattern in usually higher by 5° to 10° F. than Telengana practically throughout the year. Temperatures of 112° to 118° F. are often recorded on individual days in April and May and occasionally in June in Rayalaseema as well as North Telengana.

The mean minimum temperature rarely falls below 55° F. in Telengana even in the coldest part of the year. In some of the Rayalaseema districts (particularly Kurnool), however, it may fall sometimes to 50° F. or even less in December or January. However, frosty weather is extremely rare even in this area.

TABLE 121. MONTHLY MEAN MAXIMUM AND MINIMUM TEMPERATURES FOR SIX REPRESENTATIVE DISTRICTS OF ANDHRA PRADESH

	Locality	Month											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Telengana												
Mean maximum temperature (degrees Fahrenheit)	Nizamabad	86·5	92·0	97·9	103·5	106·9	97·2	86·9	86·4	86·7	89·5	86·0	84·6
	Warangal	85·0	90·3	96·5	101·3	105·8	97·3	87·3	87·3	86·7	88·1	85·4	83·5
	Hyderabad	83·7	90·8	95·9	100·7	103·7	94·1	86·3	86·2	85·1	87·0	84·1	82·5
	Rayalaseema												
	Kurnool	97	103	108	112	114	112	102	100	100	101	97	94
	Cuddapah	88	94	101	105	106	100	96	95	94	92	88	86
	Guntur	94	100	107	112	117	115	107	104	102	100	95	93
	Telengana												
Mean minimum temperature (degrees Fahrenheit)	Nizamabad	57·7	63·2	69·2	76·1	81·4	78·1	73·6	74·4	73·0	69·1	60·8	56·3
	Warangal	61·6	66·5	71·5	77·1	82·2	80·0	75·9	75·6	75·2	72·5	65·0	60·5
	Hyderabad	58·6	63·7	68·6	75·1	79·3	75·4	72·0	72·4	71·7	69·9	69·2	57·8
	Rayalaseema												
	Kurnool	47	52	55	61	66	68	69	66	67	55	50	44
	Cuddapah	66	70	75	81	83	81	78	78	77	75	70	66
	Guntur	54	57	53	68	66	71	73	71	71	65	56	55

The diurnal temperature range is 25° to 30° F. in the dry season from November to May, and 15° to 20° F. during the rainy season.

Rainfall. The normal annual rainfall of the principal cotton districts is shown below :

District	Annual rainfall (inches)
Telengana	
Adilabad	41.7
Nizamabad	41.5
Warangal	37.9
Karimnagar	34.9
Hyderabad	30.4
Nalgonda	26.7
Rayalaseema	
Anantapur	22.4
Kurnool	24.3
Cuddapah	27.1
Guntur	32.4

The annual rainfall in Telengana varies from about 42 inches in the districts of Adilabad and Nizamabad, 35 to 38 inches in Karimnagar and Warangal, 30 inches in Hyderabad and only 27 inches in Nalgonda. In Rayalaseema tract, the annual rainfall ranges from 20 to 22 inches in Anantapur, 25 to 27 inches in Cuddapah and Kurnool and 32 inches further east in Guntur. The western part of the Rayalaseema plain lies in the heart of the famine zone, which extends westwards into the adjoining districts of North Mysore. Due to its situation in the middle of the peninsula, this area falls within the influence of both the south-west and north-east monsoons, but it does not get the full benefit of either. There is a constant deficiency of one or the other and sometimes of both. Therefore, the rainfall of the greater part of this tract is scanty and precarious.

The monthly distribution of rain in the principal cotton districts of the State is shown in Table 122. It may be noted that the great bulk of the annual rainfall (i.e., about 75 to 80 per cent. in Telengana and 60 to 66 per cent. in Rayalaseema) is normally received during the south-west monsoon from June to September. However, Warangal and Nalgonda districts of East Telengana and all the districts of Rayalaseema benefit from the early part of the north-east monsoon also. These late rains, though not so dependable, account for 25 to 30 per cent. of the annual rainfall in Rayalaseema.

The rainfall pattern of the Region is depicted in Figure 28.

Humidity. Corresponding with the arrival of the south-west monsoon, the relative humidity of the atmosphere suddenly rises in June to about 70 per cent. It continues high (about 80 per cent.) during the rainy season,

TABLE 122. AVERAGE MONTHLY RAINFALL FOR TEN COTTON-GROWING DISTRICTS OF ANDHRA PRADESH

Locality	Month												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Telengana													
Adilabad	0·3	0·7	0·4	0·8	0·7	7·6	12·9	8·7	6·5	2·2	0·7	0·2	41·7
Nizamabad	0·2	0·9	0·5	0·9	0·6	6·5	11·6	9·5	7·6	2·4	0·6	0·2	41·5
Warangal	0·2	0·7	0·3	1·1	1·5	5·7	9·7	7·5	6·7	3·1	1·2	0·2	37·9
Karimnagar	0·2	0·9	0·5	0·8	1·0	5·7	9·1	6·7	6·5	2·5	0·9	0·1	34·9
Hyderabad	0·3	0·4	0·6	1·1	1·2	4·5	6·3	5·5	6·6	2·5	1·1	0·3	30·4
Nalgonda	0·1	0·4	0·3	0·9	1·2	3·8	4·7	4·5	5·9	3·5	1·2	0·2	26·7
Rayalaseema													
Anantapur	0·1	0·2	0·2	0·8	2·0	2·1	2·2	3·3	5·3	4·0	1·9	0·3	22·4
Kurnool	0·1	0·2	0·3	0·7	1·4	2·6	3·8	4·0	5·3	3·8	1·8	0·3	24·3
Cuddapah	0·3	0·1	0·2	0·7	1·6	2·4	3·2	4·0	5·0	5·0	3·7	0·9	27·1
Guntur	0·3	0·4	0·3	0·6	1·6	3·3	4·6	4·9	5·7	6·2	4·0	0·5	32·4

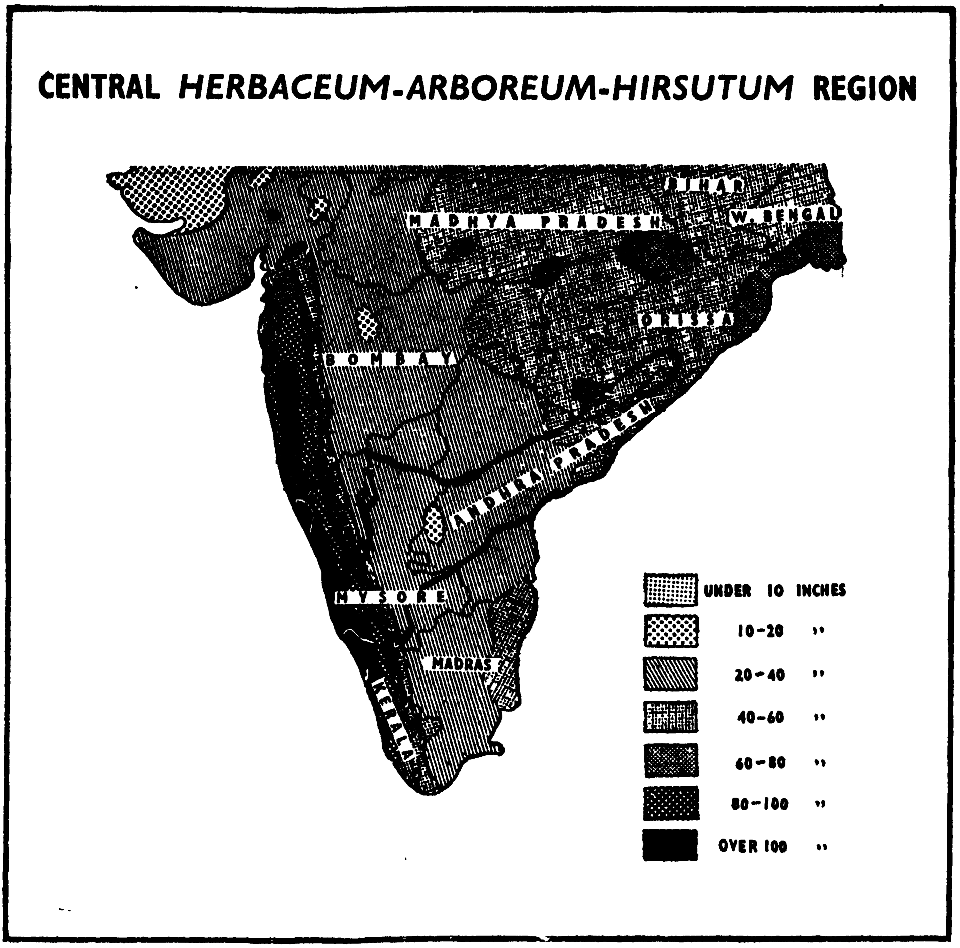


Fig. 28. **Rainfall Pattern of the Central *herbaceum-arboreum-hirsutum* Region**

and gradually decreases to 50 per cent. with the setting in of the cold dry weather. The humidity is lowest (40 to 45 per cent.) during the hot months from March to May. However, it may be mentioned that the atmosphere in the hot weather in Telengana and the irrigated parts of Rayalaseema is not so dry as in the rest of the State. Telengana is studded with a large number of water tanks and reservoirs, and canals exist in some districts of both the tracts for irrigation purposes. These and the large forest areas in the Telengana tract make the air somewhat humid in the hot season. Coastal Andhra benefits from the humid sea winds throughout the year.

MYSORE

The climate of Mysore, excepting Raichur Division, is mild throughout the year; that of Raichur Division is very similar to the climate of the adjoining districts of Andhra Pradesh and Bombay. The meteorological data for some of the important districts of the different Divisions of the State are given in Tables 123 and 124.

Temperature. In Raichur Division, the mean maximum temperature is between 90° and 95° F. in February and March, between 100° and 105° F. in April and May, and between 80° and 85° F. from June to January. During the cotton season, i.e., from June to March, the mean maximum temperature in this Division is between 70° to 80° F. from March to October, and between 60° to 70° F. in the other months. It rarely falls below 55° F.

Dharwar Division may be divided climatically into two tracts: (*i*) western Transition tract; and (*ii*) Eastern dry tract. The mean maximum temperature of both the tracts is below 100°F., even in the hot season, and the absolute daily maximum temperature seldom exceeds 104° F. The average minimum temperature is about 55° F. in December, January and February at Dharwar, and somewhat higher in the Eastern dry tract. During the remainder of the year, the minimum temperature runs between 60° to 70° F. at Dharwar and about 10° higher in the eastern tract. The absolute minimum temperature does not fall below 45° F. anywhere even in mid-winter.

The temperature of Malnad and the Maidan zones of the plateau in the winter months of December and January ranges from 62° F. in the west to 67° F. in the east. The temperature never falls so low as to prevent crop growth. The daily summer temperature in these areas seldom exceeds 100° F., while the mean monthly temperature varies from 83° to 87° F.

Rainfall and Humidity. The annual rainfall in Raichur Division varies from 20 to 22 inches in Raichur and Bellary, and 28 to 32 inches in Gulbarga and Bidar. Bulk of the annual rainfall in all the four districts is received in the south-west monsoon from June to September. In Bidar, July is the month of heaviest rainfall, whereas in Gulbarga, Raichur and Bellary, the month of September accounts for the greatest precipitation. The two last named districts, benefit from the north-east monsoon to the extent of 20 to 25 per cent. of the annual rainfall. Furthermore, the rain is usually received in heavy fall of an inch or more per hour, followed by 10 to 20 days of hot weather. The rainfall is also very often extremely local in character. Much of the water of the heavy rain storms in these districts runs off the surface instead of percolating into the soil. This loss of water in an area of deficient and precarious rainfall is a serious matter. A real shortage of soil moisture may occur even in a year of high total rainfall. Moreover, the sharp showers also cause serious erosion in some parts. Ante-monsoon thunder showers in April and May (more so in the latter month), bring light rain of not much value to cotton cultivation. The mean relative humidity is between 70 and 80 per cent. in the monsoon months from June to October, between 50 and 60 per cent. from November to February, and only 30 to 40 per cent. in the quarter from March to May.

TABLE 123. MONTHLY MEAN MAXIMUM AND MINIMUM TEMPERATURES FOR MYSORE STATE

	Locality	Month											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean maximum temperature (degrees Fahrenheit)	Bidar Gulbarga Raichur Bellary Bijapur Dharwar Belgaum Shimoga	86·3	91·9	97·1	102·0	102·2	95·4	89·9	87·2	89·1	88·9	85·4	84·7
Agricultural Research Station, Hiriyur	Citaldurg	86·0	89·6	95·5	96·4	94·1	91·8	82·3	83·8	84·7	76·5	85·8	84·1
(10 years, 1949-58)	Mandya (A.R.S.) Mysore	82·6	87·1	91·8	94·1	91·2	88·2	84·1	83·5	84·4	83·7	82·2	80·8
Mean minimum temperature (degrees Fahrenheit)	Bidar Gulbarga Raichur Bellary Bijapur Dharwar Belgaum Shimoga	63·4	65·8	72·4	77·8	77·8	71·1	73·3	71·9	72·0	71·0	65·9	62·6
Agricultural Research Station, Hiriyur	Chitaldurg	56·5	52·5	67·5	71·6	71·3	71·9	70·9	69·8	69·1	67·9	63·5	60·3
Average for five year, 1954-58	Hassan Mandya (A.R.S.) Mysore	60·3	61·0	64·4	71·2	74·7	69·7	68·4	69·4	67·8	67·8	64·2	60·1

TABLE 124. AVERAGE MONTHLY RAINFALL FOR MYSORE STATE

	District	Month											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average monthly rainfall (inches)	Bidar Gulbarga Raichur Bellery Bijapur Dharwar Belgaum Shimoga	—	—	0·30	0·64	1·61	5·85	6·10	7·37	6·02	2·21	0·44	—
Agricultural Research Station, Hiriyur	Chitaldrug	—	—	0·10	2·03	6·48	0·40	0·87	4·91	5·41	3·53	1·68	—
(10 years, 1949-58)	Hassan Mandya (A.R.S.)	0·10	0·15	0·22	2·09	6·01	1·78	3·13	2·17	4·16	9·05	2·48	0·53
Mean relative humidity at 8 A.M.	Bidar Gulbarga Raichur Bellary Bijapur Dharwar Belgaum Shimoga	80	66	61	59	68	79	88	89	86	83	78	82
Agricultural Research Station, Hiriyur	Chitaldrug	75	69	76	82	89	82	89	92	88	90	84	87
Average for five years, 1954-58	Hassan Mandya (A.R.S.) Mysore	89	82	81	83	86	86	89	88	90	93	91	91

The annual rainfall of the Transition tract of Dharwar Division is about 30 inches and it is fairly well distributed in the period from May to November. July is the month of heaviest rainfall, followed by a second but smaller peak in October. The annual rainfall in the eastern tract is about five inches less. It is also more precarious, being similar in this respect to the adjoining parts of Raichur Division. The growth of the cotton crop in Dharwar tract is also affected considerably by the winds prevailing in the period following the rainy season. The more humid westerly winds benefit the crop a great deal, whereas the dry, easterly winds produce a very adverse effect.

The annual rainfall in the remainder of the State varies from a maximum of over 300 inches in some places in Malnad to as low as 16 to 20 inches in some *talukas* of Tumkur district in the east. Malnad has an average rainfall of 60 inches, received almost wholly in the south-west monsoon season from June to September. The rains are torrential and incessant in these months, the highest amount for a single day being sometimes as high as 20 inches. The north-eastern part of the Maidan, adjoining Bellary and Kurnool districts, has a poor rainfall of 18 to 22 inches and the south-eastern part, 20 to 30 inches per annum. On the other hand, the bulk of the Maidan, forming its central zone, has an annual rainfall of 30 to 50 inches. Ante-monsoon thunder showers are also fairly common as in the Transition tract of Dharwar Division. Thus the rainy season for the central and southern parts of the Maidan extends from May to November as against June to October for the western Maidan and Raichur Division in the north. The western Maidan benefits largely from the south-west monsoon from June to September, while the eastern Maidan gets more rain from the north-east monsoon in October and November. Another important feature is that September (and not July) is the month of peak rainfall.

SOILS

ANDHRA PRADESH

The principal types of soils met with in this State are coastal alluvium; deltaic alluvium; black cotton soils; red soils; and laterite soils.

The coastal and deltaic alluviums are restricted to coastal Andhra Pradesh, where not much cotton is grown. The coastal alluviums are generally sandy soils or sandy loams, poor in organic matter and mineral plant nutrients. Deltaic alluviums, on the other hand, are usually deep and very fertile. The districts of coastal Andhra Pradesh have not only a more assured rainfall, but also possess facilities of canal irrigation. As such, the deltaic soils of this area are devoted largely to the cultivation of irrigated paddy and garden crops. Telengana and Rayalaseema are the main cotton-growing tracts. The soils of both these zones belong to the remaining three types : (*i*) black cotton soil; (*ii*) red soil; and (*iii*) laterities. Zone-wise, the soils may be described as follows :

Telengana. The soil of a great part of Telengana is granitic in origin and is locally known as *chalka*. It is red in colour and varies from finely pulverised soil to coarse grained, stony upland soil lying on a substratum of hard rock and gravel. In some parts, it is very sandy. It loses moisture quickly and is not very fertile. Not much cotton is grown in this type of soil. It is, however, fairly well suited for quick-maturing, rainy season, cereals and pulse crops. Large areas of inferior *chalka* in the undulating portions of Warangal, Karimnagar, Nalgonda and Mahbubnagar districts are devoted to castor cultivation also. Under irrigation and proper manuring, good types of *chalka* produce excellent paddy, sugarcane and garden crops. The irrigated areas of Nizamabad, Karimnagar, Warangal and Mahbubnagar grow almost exclusively the food crops and sugarcane. Practically no irrigated cotton is grown in Telengana.

It all parts of this region, more particularly in the river and mountain valleys of Adilabad, Karimnagar and Warangal districts in the north and the gently sloping tract of Khammam in the south-east, varying areas of fertile black soil or of medium black soil are also met with. The medium black soil is formed by the weathering of certain types of rocks of the archaean system and is not so fertile as the alluvial black soils of the Godavari Valley or the typical *regur* of the trap portion of Adilabad district. They, however, resemble the true black cotton soils in their principal attributes, viz., high retention of soil moisture and development of deep and wide fissures in the hot weather. The cracking of soil encourages aeration and helps to maintain soil fertility by causing a considerable mixing of crumbled surface soil with the lower layers. The cotton crop of Telengana is grown chiefly on such *regur* and light black soil. In wooded hills, large patches of lateritic soils are fairly common, but very little cotton is grown on them.

Rayalaseema. The soils of the principal cotton-growing districts of Anantapur, Kurnool, Cuddapah and Guntur are chiefly of the black *regur* variety, with occasional patches of red sandy soil at relatively higher levels. Cotton is grown on both types of soils, the late sown finer cottons being grown on the former, and the early sown, short staple, coarse varieties, on the latter. *Regur* is typically the soil of the gently sloping, more level plains or river valleys. In the valleys, it may be as deep as 20 feet, whereas on level land, its average depth varies from three to six feet, overlying largely a substratum of metamorphic rock and not trap. In many cases, the river action has transported these soils well beyond the trap zone, e.g., in Nandyal Valley. On their main agricultural properties, however, the alluvial deposits are not different from *regurs* formed *in situ*. *Regur* soil is highly argillaceous, containing a relatively high proportion of calcium, magnesium, iron and alluminium. Being rich in lime and fairly well drained, it is usually workable soon after a shower of rain. It has high base exchange capacity and water absorption power. Sometimes it contains gypsum in its profile. Usually it is poor in nitrogen, humus and phosphoric acid but contains sufficient potash to meet plant requirements. It is generally alkaline in reaction. Table 125 gives an idea of its chemical and mechanical composition.

TABLE 125. AVERAGE MECHANICAL AND CHEMICAL COMPOSITION OF BLACK COTTON SOIL

Mechanical		Chemical	
	Range		Range
Fine fraction (silt *plus* clay)	70-80%	Total water soluble salts	0·05-1·5%
Coarse sand	4-8 %	Salt concentration depth	3-7 ft.
Fine sand	15-25%	Exchange capacity	40-60mg./100 gm.
Acid solubles	2-10%	Exchangeable calcium	15-42 ,,
		Exchangeable magnesium	6-20 ,,
		Exchangeable potash	0·1-0·6 ,,
		Exchangeable sodium	3-13 ,,
		R_2O_3	25-36%
		Fe_2O_3	9-13%
		Al_2O_3	16-23%
		Lime (CaO)	2·5-7%
		Magnesium (MgO)	3-4%
		SiO_2	50-55%
		SiO_2/R_2O_3	3-4·5%
		pH	8·5-9%
		Loss on ignition	4-4·4% (average)
		Nitrogen	0·033% ,,
		Phosphoric acid	0·057% ,,
		Potash	0·49% ,,

Due to its ability to retain water, the most precious agricultural requirement in this tract of very uncertain, relatively low and short season rainfall, black soil is well suited to cotton, which comes to maturity long after the rains are over. Moreover, black soil is also better able to support the cotton plant during long periods of dry weather that often follow in the wake of heavy downpours so characteristic of this tract. Due to these reasons, *regur* or black soil accounts for about 80 per cent. of the annual cotton area of the State.

MYSORE

The soils of the re-organised State of Mysore vary a great deal from district to district as also between the different parts of a district. However, broadly speaking, they belong to the following three main groups : (*i*) *regur*, or black cotton soil ; (*ii*) red loam ; and (*iii*) laterite.

The soils of each group show great differences of texture, depth and fertility.

In Raichur Division, excepting the district of Bidar, *regur* forms the bulk of the soil. Reddish sandy and lateritic soils are also found in fairly large patches. In Bidar, lateritic and medium black soils are the principal types, the laterite occurring on higher levels and medium black soil elsewhere. In

Bellary, medium black and red soils predominate. In the valleys of large rivers, the soil is alluvial, black or red, and highly fertile. Cotton in this Division is grown on *regur* as well as on red sandy soils and laterites. ***Regurs*** and laterites are generally fertile and grow fairly good crops of the late sown Kumpta and Dharwar-American cottons, whereas red sandy soil is poor and unretentive, and is used mostly for growing early sown, short staple, Mungari cotton.

Dharwar Division, which accounts for the major portion of the annual cotton area of the State, has a variety of soils. The northern parts of Belgaum and Bijapur districts form the southern extremity of the Deccan trap. They have, accordingly, deep black, clayey cotton soils which at some places have been formed *in situ* and at others are of alluvial origin. In other localities, the soil is made up of disintegrated trap rock or *murum* and is very infertile. In the centre of the Division, the trap gives way wholly or partially to old sand stones and quartzite, producing light sandy soils. The soils of Dharwar district are formed from shales and schists and other rocks. The soils thus vary greatly from deep clayey *regur* to coarse, sandy, shallow soils of red or brown hue. As in Raichur Division, *regur* is largely used for growing Kumpta cotton, while red loams are utilised mainly for Dharwar-American. In recent years, however, an improved American cotton has gradually been displacing the Kumpta variety on black soils with varying results.

In the remainder of the State, i.e., Mysore Plateau proper and Coorg, speaking broadly, level areas with a high temperature and a rainfall of 20 to 35 inches have black cotton or *regur* soil. In regions of above 50 inches rainfall, as on the slopes of the Western Ghats in Malnad, the greater supply of moisture washes away the silicates and forms laterite. In between, where the land is rugged and the rainfall 35 to 50 inches, red sandy soils predominate. In the valleys, fertile red loams are commonly met with.

As in the adjoining States of Andhra Pradesh and Madras, red soils are usually sandy, coarse in texture, unretentive and poor in humus, phosphoric acid and lime. They are typically *kharif* crop soils and are not good for *rabi* crops except under irrigation. They are best in seasons of light and frequent rains. Good red soils of the more level parts of the Maidan are sandy clays, coloured red by iron peroxide and formed *in situ* from metamorphic rocks. In the river valleys, they are deep and rich, carried down by the river, or washed down the valley slopes. Under irrigation and proper manuring, they produce excellent crops of high quality cotton. Laterite soils are light, porous and water-hungry. Under irrigation and good manuring, they produce excellent garden crops. On wooded hill slopes, they are rich in forest humus, but deficient in lime and phosphoric acid. They are easily workable and good for coffee planting. The black cotton soils are poor in nitrogen (0.04 to 0.15 per cent.) and phosphoric acid (0.02 to 0.10 per cent.), but rich in lime and aluminium and well provided with potash.

Cotton is grown on both black and red soils. The deep-rooted Asiatic varieties are grown on black soils (as in Chitaldrug and eastern Shimoga) and the American varieties on well drained red loams. Wherever possible, the American types are grown under irrigation or in tracts where the rainfall is relatively high (about 40 inches) and the rains start early in May and are usually well distributed as in the western parts of Hassan district. In the canal irrigated parts of Mandya district where well drained red loams and red sandy loams constitute the predominant soil types, cotton is grown as an irrigated crop. Under irrigation tanks and springs, the soils are rich and clayey, but they are chiefly used for growing paddy and other food crops.

ANDHRA PRADESH

CULTIVATION OF CROP

Crop Season. Practically the whole of the cotton crop of this State is grown as a rainfed crop. Only an insignificant portion is grown on well irrigation in rotation with sugarcane and other garden crops.

In Telengana, cotton is grown either as a *kharif* crop (June to December or January) or as a *rabi* crop (mid-September to March or April). In Karimnagar, Adilabad and Warangal districts, the *kharif* cotton forms the bulk of the crop, whereas in Nizamabad, Mahbubnagar, Nalgonda and Khammam the greater area is under the *rabi* crop.

In Rayalaseema and the districts of Nellore and Guntur, the crop on the light red soils is grown in the *kharif* season (*mungari* crop), while that on the retentive black soils is grown as a *rabi* or *hingari* crop (August to April). On the deep black soils of Krishna district, cotton is grown wholly as a *hingari* crop.

In the Chinnapathi area of Visakhapatanam and Srikakulam districts, having a rainfall of 40 to 45 inches, the season for the crop on red or gravelly soil extends from June to January (*tholakari*) and for that on the clayey wet land soils, from December-January to July-August (*buradapathi*).

Depending on the soil and season of crop growth, the *kharif* crop in Telengana and on the light red soils of Rayalaseema is sown with the commencement of monsoon rains in June. In some parts of Warangal, it is sown as late as the end of July. On the other hand, the *rabi* crop in Telengana is sown from mid-September to mid-October. In the southern parts of Nalgonda and Khammam and on the black soils in Rayalaseema, it is sown in the latter half of August or early September, when the soil has already received sufficient rain in the preceding two months. In the Chinnapathi tract, the crop on red soils is sown in June and that on clayey wet lands in December, as a second crop after paddy.

Rotation. In Telengana, cotton is usually rotated with *kharif* or *rabi* *jowar* (*Sorghum vulgare* Pers.) in a two-year rotation. Occasionally, cotton follows a crop of maize, castor, bullrush millet, groundnut, sesamum, linseed, chillies, tobacco, *ragi* (*Elusine corocana*) or another crop of cotton. The *rabi* crop in some *talukas* of Adilabad is rotated with wheat, gram or paddy. In rare cases, cotton may be grown after cotton, or after a fallow. In many districts, the two-year cotton-*jowar* rotation is being gradually converted into a three-year groundnut-cotton-*jowar* rotation. Besides the growing of cotton in rotation, mixed cropping and inter-cropping are quite common. The *kharif* cotton is seldom grown as a pure crop. Paired rows of *tur* (*Cajanus indicus* Spreng.) are planted after every 10 to 15 rows of cotton in Adilabad, Warangal, Nizamabad and Karimnagar districts. In some parts of South Telengana, castor, groundnut, *jowar*, *ragi*, *bajra* (bullrush millet) and sesamum take the place of *tur* as an inter-crop. One or two rows of the subsidiary crop are planted after every four to six rows of cotton. The mixing of small quantities of seed of one or more of other *kharif* crops, such as *jowar*, *ambadi* (*Hibiscus cannabinus*), castor, *mug* (*Phaseolus mungo*), *bhendi* (lady fingers), or maize, with *kharif* cotton seed is also a very common practice all over Telengana. The *rabi* cotton is usually grown pure. Occasionally, rows of *kuthi* (*Doliches biflora*) or a late sown variety of *mug* are planted after every few rows of cotton.

The crop in Rayalaseema district also is grown in a two-course rotation, the rotation crop being mainly *jowar*, and sometimes *cumbu* (bullrush millet), *ragi*, small millets, groundnut, tobacco, chillies, gingelly, pulses like black gram, green gram, etc. In the wet land soils of Chinnapathi tract, cotton is grown after a crop of paddy. As in Telengana area, a three-year rotation of groundnut-cotton-cereals is increasingly finding favour with the farmers. Furthermore, mixed cropping is commonly practised. The *mungari* crop may be sown pure or mixed with *setaria*, groundnut, etc. Similarly, the *hingari* crop, if sown in July-August, is inter-cropped with a few rows of *setaria* (*korra*) after every row of cotton. Sown in September, the *hingari* cotton is grown unmixed. In East Godavari district, cotton is sometimes grown mixed with chillies or dry paddy. The rainfed *hirsutum* cotton cultivated on red loamy soils of Anantapur and Cuddapah is usually grown mixed with Asiatic cottons. The growing of mixtures of crops is deemed an insurance against the risks of farming in an area of highly caparacious monsoon.

Preparation of Land. The preparatory cultivation for cotton in the whole of the State is of a light type. The pulverising of soil to a depth of four or five inches is considered adequate for cotton. Moreover, the extremely hard condition of the soil in the hot weather preceding the cotton season does not permit any deeper cultivation with bullock-driven implements. The need for completing the early (i.e., *mungari*) sowings in as short a time as possible is another factor that militates against a thorough preparation of soil. The land for the *kharif* or the *mungari* crop is, therefore, usually prepared by harrowing it three or four times with *bakhar* (also called *guntaka*) or the blade-harrow. Some cultivators use *gorru* (indigenous seed drill with the seed tubes removed) for the same purpose. Preparation of land is started with the first showers of the south-west monsoon in June. However, if sufficient ante-monsoon rain is received in April or May, harrowing is taken up earlier, and may be preceded by a quick ploughing given with either the indigenous, wooden plough or a light iron plough. If the soil is heavily infested with deep rooted grasses like *hariali* (*Cynodon dactylon*) or *kunda* (*Cyperus rotundus*) the weeds are either dug out by hand labour, or removed by deep ploughing done with heavy iron plough operated by four or five pairs of bullocks. This deep cultivation is seldom given oftener than once in four or five years.

The land for the *rabi* or the *hingari* crop in Telengana and coastal districts is given three or four ploughings in June and July, when the soil has been softened by the monsoon rains. In Rayalaseema district, the land is prepared by working it repeatedly with *gorru* and *guntaka* alternately.

Manuring. The cotton crop is usually grown unmanured. Only in rare causes, five to ten cart loads of farm yard manure per acre are applied to cotton once in four or five years. More commonly, the cattle manure is applied to either the food crop, particularly *sorghum* and *setaria,* grown in the rotation or to garden crops like fruits, vegetables and sugarcane . Four or five cart loads per acre is the usual rate for sugarcane. Manure is spread and mixed with the soil by harrowing before the arrival of the monsoon rains. In paddy-growing areas, all the available manure and village refuse are reserved for use on the rice crop. The use of cow-dung as domestic fuel in rural areas is as common in this State as in others; hence, the acute shortage of farm yard manure. Furthermore, since all the *hingari* crop depends almost wholly on the moisture stored in the soil during the preceding monsoon, the cotton plants cannot make full use of the manure even if it is applied directly to them. For the same reason the application of chemical manures in this area of low and uncertain rainfall has not been found to benefit cotton; often it has actually proved harmful to the crop, particularly in years of low rainfall. On the other land, the growing of groundnut, preceding cotton in the rotation, has usually had a beneficial effect on the latter.

Method of Sowing. The crop is usually sown in lines. However, in some parts of southern and central Telengana and in the districts of East Godavari, Visakhapatanam and Srikakulam, the seed is sown broadcast and covered by a blade-harrow or an indigenous plough. The line sowing in North Telengana is done by a single tube, wooden drill (called *mogha*), which is usually operated behind a blade-harrow or a *desi* plough. In eastern and central Telengana, the line sowing is carried out by dropping the seed by hand in shallow furrows behind a country plough. On the other hand, in southern Telengana and all the remaining districts of the State, the seed is commonly sown by a two- or three-tined indigenous drill, called *duffan*, *tiphan* or *gorru.* To separate the seeds from each other and facilitate their passage through the drill tubes, the seed to be sown in commonly rubbed with a mixture of mud or ash and fresh cow-dung. The spacing between adjacent cotton rows varies from 15 to 36 inches, depending on whether cotton is sown as a pure crop or is grown mixed with an inter-crop. The stand in the drill rows is usually thick; thinning of the crop is not practised anywhere in the State. The seed rate varies from about 10 to 24 lb. per acre, according as the crop is sown pure or inter-cropped. The broadcast sowing usually requires a higher seed rate. The growing of relatively early maturing, non-branching, sympodial varieties permits a thick stand and this also accounts for the comparatively large quantity of seed required for sowing a unit area. Gaps in the rows, if any, are seldom replanted. In Guntur district, most of the cultivators gin their produce at home with wooden gins and retain their own seed for planting. In the remaining parts of the State, very few farmers retain their sowing seed. The vast majority of them procure it from ginning factories or village merchants. In Adilabad and Anantapur, supplies of improved seed are made by the Government Agricultural Department.

Weeding and Interculture. The crops sown broadcast receive one hand-weeding and one or two hand-hoeings with sickle-shaped hand-hoes, called *khurpies* in North Telengana. The line sown crops in Telengana are given one thorough hand-weeding both in and between the rows when the plants are five to six inches in height. The weeding of the *kharif* crops is done a second time if the weeds re-appear in abundance, otherwise the crop is bullock-hoed three or four times with *kholpa* (also called *dauri* or *danthi*), which is an implement similar to the blade-harrow but much smaller. As elsewhere in the black cotton soil tracts, usually two or three bullock-hoes are yoked to one pair of bullocks and operated simultaneously in adjacent inter-row spaces. The *rabi* or the *hingari* crop usually receives a larger number of hoeings than the *kharif* or the *mungari* crop. The black soils on which the *hingari* cotton is grown cracks badly in the dry, summer months. Cultivation usually ceases when the plants start flowering.

In Rayalaseema, the inter-cultivation is done wholly by bullock-drawn implements. Occasionally the crop is inter-cultivated by ploughing in between the rows.

HARVESTING AND YIELD

Depending on the date of sowing and the variety grown, the crop comes into maturity at different times of the year. The *mungari*, the *kharif* and the *tholakari* crops, sown in June, are harvested from October to December and sometimes in January, whereas the *hingari* cotton sown in August-September, is picked in the period from February to April or May. The Cocanadas crop sown in July-August is harvested from January to March. On the other hand, the *buradapathi* crop, which is sown in paddy lands in December-January, is harvested in July-August. Similarly, the American variety, Cambodia, sown in August-September, produces ripe cotton from February to April.

Usually, three or four pickings are taken at successive intervals of two or three weeks. The second picking is generally the heaviest and the most important. The varieties grown (excepting Cambodia and Parbhani-American) are small-bolled. The pickings are done by women and children, wages being paid in kind as an agreed portion of the day's output. The produce is picked rather carelessly, so that a relatively high blow-room loss is characteristic of most of the produce of this State. Cambodia and Parbhani-American, being large-bolled types, are picked in a comparatively clean condition.

The yield per acre is usually low, ranging from 200 to 300 lb. of seed cotton per acre. Generally speaking, it is more for the *kharif* (or *mungari*) crop than the *rabi* (or *hingari*), greater for short staple varieties than for those having medium or long staple, and higher for areas of more assured rainfall (as Adilabad district) than for the low and very uncertain rainfall tracts of Rayalaseema.

The standard normal outturn of lint used for official forecasts of production for different districts is given in Table 126.

TABLE 126. STANDARD NORMAL OUTTURN OF COTTON LINT FOR DIFFERENT DISTRICTS OF ANDHRA PRADESH

District	Outturn of cotton lint (lb. per acre)
Karimnagar	80
Adilabad	85
Nizamabad	70
Warangal	80
Nalgonda	70
Medak	70
Mahbubnagar	75
Khammam	80
Anantapur	80
Kurnool	50 (100 for Mungari)
Cuddapah	50 (80 for Mungari)
Nellore	50 (75 for Cocanadas)
Guntur	75
East Godavari	75
Krishna	75
Srikakulam	50
Visakhapatanam	50

After the completion of the harvest, goats, sheep and cattle are let in to graze but the plant stalks are not removed until the annual tenancies are renewed or, in the case of peasent proprietors, threshing operations of food crops are completed and an odd shower in the hot season permits of stubble clearance by blade-harrowing. Cotton stalks are normally consumed as fuel, but sometimes they are used for thatching village huts.

IMPROVED VARIETIES

Crop improvement work for the production of high yielding and better quality varieties suited to different environmental conditions has received due attention. Improved varieties are now under extensive cultivation in all parts of the State. Their distinguishing characters and distribution are shown in Table 127.

Parbhani-American is resistant to jassids but is slightly late maturing. Laxmi cotton, though resistant to red leaf blight, is highly susceptible to blackarm disease. Between the two Cocanada varieties, Cocanadas 2 is superior in the intensity of lint colour. Experimental work with a number of improved Mungari varieties, produced locally or imported, has been in progress for some years, but none of them has so far been finally selected for commercial cultivation.

MARKETING AND GINNING

Practically the entire produce is marketed in the form of *kapas* or seed cotton. Very few cultivators gin their produce themselves, or on their own account and sell lint. Regulated markets established under the Hyderabad Agricultural Produce Markets Act exist at 39 places in Telengana, and 10 of them deal in cotton besides other produce. Brokers, weighmen and warehousemen operating in these markets are licensed; fees and trade allowances charged by various parties are fixed; uniform weights and measures are prescribed; sale of cotton by public auction is made compulsory; and provision exists for the arbitration of matters in dispute between sellers and buyers. In Adilabad district, arrangements are made with the buyers annually by the Government Agricultural Department for the purchase of the pure produce of the Reserved Areas of Parbhani-American and Gaorani 6 at a premium over ordinary produce. As a part of this arrangement the Agricultural Department purchases the resulting pure seed at a small premium for supply to cultivators for sowing in the following season. Co-operative marketing of cotton is almost completely non-existent.

A well organised and regulated market functions at Adoni in Rayalaseema. Market yards have also been organised at Nandyal, Tadpatri and Guntakal, where cotton merchants from Bombay and representatives of some South Indian textile mills make purchases of raw cotton. Marketing of small quantities in the interior villages is handled by village merchants.

The facilities for ginning and pressing cotton are adequate in almost all parts of the State. Ginning factories exist at Adilabad, Karimnagar, Warangal, Nirmal, Nizamabad, Khammam, Adoni, Guntakal, Tadpatri, Nandyal, Nandikotkur, Guntur, Narasaraopet and many other smaller places. The

TABLE 127. DESCRIPTION AND DISTRIBUTION OF IMPROVED VARIETIES OF ANDHRA PRADESH

Variety	Species	Districts of cultivation	Statistical position		Characteristics						
			Annual area (thousand acres)	Production of lint (bales of thousand 392 lb.)	Average yield		Ginning outturn (per cent.)	Staple length (32nd inch)	Fibre weight per inch (millionth of an ounce)	Average mill spinning capacity (warp counts)	Blow-room loss (per cent.)
					Kapas (lb. per acre)	Lint (lb. per acre)					
Parbhani-American 1	*G. hirsutum*	Adilabad	120	30	250-300	80-110	32-33	28	0·144	24-28's	8-10
Gaorani 6	*G. arboreum* var. *indicum*	,,	100	25	250-300	80-90	31-32	28-30	0·172	26-28's	6-10
Westerns 1	*G. herbaceum*	Anantapur Kurnool Cuddapah	180	50	200-250	60-70	28	26	0·195	24's	10-12
Laxmi	*G. hirsutum*	,,	100	25	250-300	85-100	33	28-30	0·134	30's	6
Nandyal 14	*G. arboreum* var. *indicum*	Kurnool	30	4	250-300	60-70	24-25	28-30	0·166	30-32's	8-10
Cocanadas 1 and 2	*G. arboreum* var. *indicum*	Guntur Nellore Krishna	55	8-10	250-300	70-80	28	24-26	0·182	20-24's	6-12

produce of Nellore district is taken to Guntur and Narasaraopet for ginning. With the introduction of cotton as a second crop in the rice fallows of the coastal districts, namely, Nellore, Krishna, and East and West Godavari, the setting up of market yards as well as ginning establishments is being encouraged in this area.

The total number of factories for processing *kapas* and lint exceeds 30, but about eight of them, located in Nizamabad, Warangal and Karimnagar districts, remain silent due to fall in cotton production. Four-fifths of the factories have cotton ginning and pressing machinery only, and the remaining establishments are additionally equipped with machinery for decorticating groundnut, pressing oil from seeds and milling rice or flour. In addition to these large factories, a number of small establishments, each having four to eight gins, exist in interior villages. However, not all the ginning factories are operated every year. Under a system of common pool in vogue in several centres, some of them are kept idle in turn in each such locality, but they share in an agreed manner in the net profits of the operating ginneries.

A majority of the factories do ginning on custom. Very few factory-owners purchase *kapas* outright from farmers or village merchants and gin it on their own account.

Platt's single-roller gins constitute the predominant type of ginning machinery in use. In Karimnagar district of Telengana, some of the factories are equipped with double-roller gins. The number of gins in a factory varies from four to forty. Factories are worked either by steam or by internal combustion oil engines, the latter supplying the motive power for most of the small factories. *Kapas*, lint and seed are handled by manual labour; mechanical automatic conveyors are unknown. The factory compounds are usually littered with loose lint. Very few factories have paved platforms or satisfactory godowns for storing *kapas*. Produce is usually stocked in the open, only a tarpauline covering being provided in inclement weather.

The pressing machinery is almost entirely of the hydraulic type. Proper export bales, each weighing 392 lb. net of lint, are neatly made. The charges for ginning and pressing are fixed by the Government. Malpractices, such as watering of cotton, mixing of different varieties and false packing are usually non-existent. They have been made a penal offence under the State Factories Act for the licensing of ginning and pressing factories.

PESTS AND DISEASES

Pink bollworm (*Platyedra gossypiella* Saund.) and spotted bollworm (*Earias* sp.) are the principal insect pests of the crop in Andhra Pradesh. Between them, they cause a loss of 15 to 20 per cent. of the annual output. The damage is especially noticeable in localities growing both the *kharif* and the *rabi* (i.e., *mungari* and *hingari*) crops in immediate neighbourhood. The loss is also heavy in seasons of heavy, late rains. Late maturing varieties suffer more heavily than early types. The cultivation of early maturing varieties, the removal of cotton stalks immediately after the end of the harvest season, filling up of soil cracks by harrowing in the dry weather and abstaining from the growing of alternative host plants (like lady fingers, hollyhock and *ambadi*) in the 'no cotton' season have been found effective remedial measures.

Jassids (*Empoasca* sp.), thrips, aphis and leaf rollers (*Sylepta derogata* F.) are some of the other pests afflicting cotton, particularly of American varieties. Types resistant to jassids have been evolved and put into large-scale cultivation. With the introduction of the jassid-resistant Parbhani-American in Adilabad district, and of Laxmi and Cambodia cotton in Anantapur and Cuddapah, this pest has lost much of its importance. Jassids can also be controlled by sulphur dusting. Thrips can be controlled by spraying with nicotine sulphate, and aphis with tobacco decoction or nicotine soft soap solution. Leaf rollers are usually destroyed by hand-picking. Cotton stainers and dusky cotton bugs appear occasionally on maturing bolls but rarely do any serious damage.

Amongst plant diseases, *Fusarium* wilt causes some damage to Asiatic cottons in isolated localities but it is of no great importance anywhere in the State. Dry rot, *Marcophomena phaseoli* (Maubl.) Ashby, destroys young seedlings, sometimes in large numbers, on heavy black soils. The damage is particularly heavy when a spell of hot weather follows a few days of incessant rain soon after the germination of seed. Yet another disease, namely, blackarm (*Bacterium malvacearum* E. F. Sm.) has recently appeared in some parts of Kurnool and Anantapur districts with the extension of area under Laxmi cotton, which is susceptible to this disease. No remedy has been discovered as yet for this malady.

Stenosis (smalling or small leaf disease) does extensive damage, sometimes, to *herbaceum* cotton. Plants suffering from it remain stunted and produce small-sized leaves and abortive flower buds and bolls. Stenosis is a virus disease. No remedial or control measures have been discovered as yet.

Red leaf blight also takes a heavy toll in some areas. It afflicts some types of American cotton, those with hairy leaves being less susceptible. The leaves turn yellow and then red. The affected leaves gradually dry up and are shed. The afflicted plants also suffer from a heavy shedding of bolls, which reduces the crop yield considerably. The malady is ascribed to physiological upsets, though jassids are often found associated with it. Nitrogenous manuring and better cultivation are said to diminish its severity. Resistant varieties have also been produced.

ECONOMICS OF PRODUCTION

No reliable statistics of the economics of cotton production in Andhra Pradesh are available. However, it may be mentioned that cotton is not of major importance in Telengana tract except in Adilabad, Karimnagar and

Khammam districts. With a large area of well drained soil growing paddy under tank and canal irrigation and the soils of the remaining area being light and unrententive and dependent on a precarious rainfall for successful cultivation, Telengana is pre-eminently the land of rice, *jowar* and castor crops. In recent years, the cultivation of groundnut has increased in many districts at the expense of cotton. Being a relatively short season crop, groundnut has been found well suited to the soil and climatic conditions of this region. Furthermore, due to its higher yield, and a rapidly expanding demand for its oil and cake, it has proved more remunerative than the fibre crop. Its beneficial effect on soil fertility and texture has been an additional attraction. The fixing of reasonable floor prices for cotton by the Government has stemmed the rot to some extent.

In coastal Andhra also, cotton is not of great importance. Rice, chillies, tobacco, sugarcane, other garden crops and coconut occupy the largest area. Recently, the cultivation of an early maturing American cotton as a second crop in rice fallows, after the harvest of the food crop, in November-December, has been introduced successfully in some parts of this tract. This off-seasonal crop gives an yield of 700 to 800 lb. of seed cotton or about 250 lb. of good quality lint, without affecting the yield of the succeeding paddy crop. Cultivation of American cotton under these conditions is likely to prove an economic proposition in these districts.

Rayalaseema has very large areas of retentive, deep black soils, on which cotton can be grown fairly well. Cotton, therefore, occupies an imoprtant position in the cropping system of this zone. The introduction of better priced and more productive improved varieties has made its cultivation more remunerative, yet if cotton is to continue as an attractive crop, its yield per acre must be increased by means of intensive cultivation. The provision of irrigation facilities in the areas commanded by the Tungabhadra irrigation project permits not only the growing of better priced, high quality, American varieties but also the direct manuring of the cotton crop. This is bound to increase the yield considerably and thus make the cultivation of the crop more profitable. Where irrigation facilities are not available, the adoption of improved 'dry farming' methods have been encouraged with good results for the economics of cotton cultivation.

SEED MULTIPLICATION AND DISTRIBUTION

The multiplication and distribution of pure seed of improved cotton varieties Gaorani 6 and Parbhani-American 1 in Adilabad district were carried out formerly under the special schemes operated for the purpose, by the Government of the former Hyderabad State. With the re-organisation of the State in 1956, this work was taken up by the Government of the new State of Andhra Pradesh. With the financial aid of the Indian Central Cotton Committee, a scheme was sanctioned to establish a Government Seed

Farm of 100 acres at Bhainsa in Adilabad district for the multiplication of pure Gaorani 6 seed. The seed of Parbhani-American, on the other hand, is multiplied in selected villages, on private farms of 'registered' cultivators, who grow the crop under the Agricultural Department's supervision from the seed supplied by the Government and sell the produce in accordance with the marketing arrangements made by the State Agriculture Department. Under these special arrangements, the produce is ginned under official supervision and the Government has the first option on the purchase of pure seed required for distribution to cultivators for sowing in the following season. This system works well to maintain the purity and reputation of this improved variety.

The multiplication and distribution of pure seed of Westerns 1 and Cocanadas 1 and 2, which are recommended for cultivation in the districts of Anantapur, Kurnool, Cuddapah and Guntur, formed part of the arrangements made by the former composite State of Madras. With the establishment of Andhra Pradesh as a separate entity, these arrangements ceased. The Government of the new State of Andhra Pradesh is actively considering the revival of the required arrangements under its own auspices. Furthermore, to meet the needs of the growers of Laxmi cotton in Anantapur, Cuddapah and Kurnool districts, the State authorities have made interium arrangements for private parties to procure pure seed of this variety from reliable sources in Gadag area of Mysore State.

The area planted with improved varieties in 1955-56 was about 6,10,000 acres, or nearly 52 per cent. of the total area of 11,95,000 acres sown with cotton in that year.

UTILISATION OF COTTON SEED

The average annual production of cotton seed is about 55,000 tons. About 10 to 12 per cent. of this quantity is needed for sowing purposes and another 30 per cent. as feed for working cattle and milch cows and buffaloes. A very small quantity is crushed locally by village *ghannies* and the oil is used for lighting and the lubrication of cart wheels. The remaining seed finds its way to large or small oil mills for crushing. In areas where cultivators sell their produce as *kapas* (unginned cotton), they meet their requirements of planting seed and cattle feed by purchases from village or town merchants. The oil produced by the mills is partly used for industrial purposes and is partly hydrogenated for use as edible, vegetable *ghee*. The cotton seed cake is almost wholly used as cattle feed. Not all the local production of cotton seed, oil and cake is used within the State itself.

COTTON LEGISLATION

Regulated Cotton Markets. The State has regulated markets for cotton at ten places in Telengana and five places in the remainder of the

State. The markets in Telengana have been set up under the Hyderabad Agricultural Produce Markets Act (No. II of 1939 F.) and those in Andhra area, under the Madras Commercial Crops Market Act. The marketing of cotton (ginned or unginned) is controlled and supervised in these localities. As already mentioned, these markets give the cotton grower a fair deal by securing the best possible price for his produce and protecting him against the levy of unauthorised or exorbitant trade allowances or other deductions.

Cotton Protected Areas. The tract growing Northerns and Westerns cottons formed a protected area under the Cotton Transport Act of the composite Madras State. The Government of the new State of Andhra Pradesh is actively considering arrangements to continue this area as 'protected' for maintaining the purity of these varieties.

Similarly, the Nirmal *taluka* of Adilabad district growing Goarani 6 formed part of the Gaorani Protected Area constituted under the Hyderabad Cotton Cultivation and Transport Act (No. VI of 1337 F.). This Act not only prohibits the import of *kapas* and seed of short staple varieties into the protected area, but it also prescribes the compulsory cultivation of Gaorani 6 cotton therein. Under the Act, the State Government is required to supply pure seed of Gaorani 6 to all cotton growers at the prevailing market price.

Control of Cotton Ginning and Pressing Factories. Section 63 of the Hyderabad Factories Act (No. IV of 1337 F.) requires the compulsory licensing of the cotton ginning and pressing establishments in the State. The provisions of the licence prescribe the serial numbering of each bale pressed by a factory and penalise admixture, watering, false packing and other similar malpractices. The Act is in force in Telengana and the proposal to extend it into the other parts of the State is under consideration.

MYSORE

CULTIVATION OF CROP

Crop Season. As in the adjoining State of Andhra Pradesh, the bulk of the crop in the enlarged State of Mysore is grown as rainfed. Out of the annual cotton area of 2.28 million acres, the area of irrigated crop is only about 25,000 acres. Irrigated cotton is predominantly grown under Irwin Canal in Mandya district. The area of well irrigated cotton is very small, and is not confined to any particular district.

There are two main seasons for rainfed cotton in this State, namely, the *kharif* (also called *mungari*) extending from June to January, and the *rabi* (also termed *jawari* or *hingari*), covering the period from August-October to April-May. In areas in which the monsoon rains start in May, cotton season begins that month. The season for irrigated cotton lasts from October to April-May, but in some parts of the Irwin Canal tract, the crop occupies the land from February to September-October.

In the Raichur Division, the crop of Bidar district is grown wholly in the *kharif* season, the period from 15th June to 15th July being the normal sowing period. The harvesting season extends from November to the end of January. In Gulbarga district, nearly one-third of the crop is grown in the *khairf* season, and the remainder in the *rabi* season. On the other hand, in Raichur and Bellary districts, about 90 per cent. of the crop is grown in the *rabi* season, and only the remainder, in the *kharif* season. The normal period of sowing in these three districts lasts from 15th June to 15th July for the *kharif* crop and from 15th August to the end of September for the *ràbi* crop.

In the Dharwar Division, the *kharif* crop is sown from the middle of June to the end of July and the sowing of the *rabi* crop is carried out in the second fortnight of August or early in September in the Transition tract, and during September-October in the Eastern tract.

In Mysore Plateau proper, the sowing season varies with the variety, and date of commencement of monsoon rains, and depending on whether the crop is grown rainfed or irrigated. The *herbaceum* varieties, which are grown almost exclusively on water-retentive black soils, are sown in August or September. The sowing of Dharwar-American varieties, grown on well drained, red loams, begins in the middle of May in the *kar ragi* tract (where the rains commence early), and in June elsewhere, and is continued till the end of July. The short staple *arboreum* cotton, grown on lighter soils, is sown in June-July. The irrigated crop of the Cambodia and Mysore-American varieties may be sown in October or February-March. The crop sown in February-March is said to suffer less from pests and diseases and to give a relatively high yield.

Rotation. In the Raichur Division, the cotton crop of Bidar district is usually rotated with the *kharif* or the *rabi jowar*. It is sometimes grown in rotation with gram, groundnut or wheat, and very occasionally after another crop of cotton. In Gulbarga district, the *kharif* cotton is rotated with the *kharif* or the *rabi jowar*, *bajra* (bullrush millet), groundnut and sometimes castor and *kangni* (Italian millet), while the rotation crops for the *rabi* cotton are the *rabi jowar*, wheat, gram, linseed and occasionally the *kharif jowar*, *kangni*, *kulthi* (horse gram), *bajra*, *ragi* and *tur* (*Cajanus indicus*). In some parts, cotton is occasionally grown after a crop of rice or sugarcane. Mixed cropping of the *kharif* cotton with *tur*, *ambadi*, *til* (*Sesamum indicum*), *red jowar* and *urid* (*Phaseolus radiatus*) is a common practice, but the *rabi* cotton is usually grown unmixed. In Bidar district, paired rows of *tur* are generally planted after every eight or ten rows of cotton.

In the Dharwar Division, a two-course rotation of cotton and *jowar*, or a three-course rotation of cotton, *jowar* and groundnut are commonly practised. In the Eastern tract, another three-course rotation of cotton, *jowar* and wheat is also pretty common. Generally cotton is grown unmixed, but sometimes, particularly in the Eastern tract, it is grown with a sprinkling of *kulthi* and *ambadi*. Similarly, in some parts of the Transition tract, cotton and groundnut are inter-cropped, being sown in separate rows in the same field.

The common rotation for indigenous cotton (*sannahatti*) on black soils in Mysore Plateau is a two-year rotation, consisting of cotton and *jowar* (*sorghum*). With the introduction of groundnut cultivation, the leguminous crop has displaced cotton on a part of the area, so that under these conditions, *jowar* occupies half the land and cotton and groundnut the other half, the relative area under the last two being dependent on their prevailing prices. Sometimes, indigenous cotton is grown in rotation with groundnut, tobacco, chillies or *ragi*. In years of favourable rains, double cropping is practised in certain areas and a quick-maturing crop of black gram, green gram, gingelly or coriander is taken as an early season crop, followed by cotton, Bengal gram, wheat or *jowar* in the *rabi* season. The rainfed American cotton is usually grown in rotation with the main season *ragi* and *kar ragi*, i.e., early sown *Eleusine coracana*. Sometimes it is rotated with horse gram and castor also. In recent years, the growing of a Punjab variety of American cotton in rice fallows as a second crop after paddy has been taken up with some success. The irrigated American cotton on red soils is rotated with rice, irrigated *ragi* or tobacco, and on heavier soils, with sugarcane, rice, Bengal gram and a number of garden crops.

Mixed cropping is a common practice for late sown indigenous cotton. In such instances, *navane* (*Setaria italica*) and *sajje* (*Pennisetum typhoideum*) are grown as inter-crops. Three to five rows of cereals are planted after every row of cotton. The cereals are harvested about three months after sowing, and the space occupied by them is ploughed up or harrowed soon after harvesting to encourage the growth of the cotton crop. The *mungari* crop may be inter-cropped with red gram, or grown mixed with a small proportion of *jowar*, castor or pulses. The American cotton is mostly grown un-mixed. However, in the Davanagere area, American cotton grown on reddish-black or light black soils is inter-cropped with groundnut, two rows of the latter being sown after every row of cotton.

Preparation of Land. The pre-sowing cultivation does not differ much from that of the neighbouring States of Bombay and Andhra Pradesh. The land for the *khairf* crop is given one or two ploughings in the hot weather on the advent of the ante-monsoon rains. This is followed by repeated harrowing with the blade-harrow. The clods crumble with the first heavy fall of rain. The use of blade-harrow thereafter producees a fine seed bed. Sometimes a clod crushing beam (*khoradu*) is used to pulverise the clods in stiff soils. Fields meant for the *hingari* crop are ploughed with the light plough after the south-west monsoon begins. They are repeatedly worked thereafter with the blade-harrow in June and July to keep down the weeds and secure good tilth. Lands infested with deep-rooted grasses like *hariali*

(*Cynodon dactylon*) and *kunda* (*Cyperus rotundus*) are cleared in the summer months by hand-digging with pick-axes or deep ploughing with heavy iron ploughs.

Land for American cotton is prepared a little more thoroughly. Immediately after the harvest of *kar ragi* at the end of August, the soil is ploughed and stubbles are removed. Thereafter, the blade-harrow is worked repeatedly to conserve the moisture from the late rains. With the commencement of ante-monsoon rains in the following summer, the soil is ploughed and harrowed again in preparation for the cotton sowings in the second half of May.

In the case of irrigated cotton, the land is flooded a few days before sowing. When in fit condition, it is ploughed and cross-ploughed to obtain good tilth.

Manuring. The indigenous varieties of cotton (*mungari* as well as *hingari*) are seldom manured directly. The available farm yard manure is reserved for the food crops (principally *jowar*) in the rotation. Due to the inadequacy of the manure available, even *jowar* is not manured regularly, and the rate of application seldom exceeds five cart loads (2 tons) per acre. When *desi* cotton is inter-cropped with millets, farm yard manure at five cart loads per acre is applied and worked into the soil by a blade or a close-tyned harrow some days before sowing. Rainfed American cotton usually receives five to eight cart loads of farm yard manure per acre. Irrigated American cotton, on the other hand, is generally green manured with sunnhemp (*Crotolaria juncea*) or a mixture of sunnhemp, cow peas and horse gram. The green manure seed is sown at 60 lb. per acre about three months before cotton sowings and when eight to ten weeks old, it is ploughed into the soil. Some farmers manure the leguminous crop with superphosphate at one hundred-weight per acre, while others supplement green manuring by top-dressing cotton with a small quantity of ammonium sulphate and/or oil-cake. In recent years, manuring of irrigated cotton with ammonium sulphate at 50 to 80 lb. of nitrogen per acre has been gaining popularity. Half the quantity of this fertilizer is applied at sowing time and the other half as top-dressing six to eight weeks later.

Method of Sowing. Except for some parts of the Raichur district, where the seed is still sown broadcast, the entire crop of the State is planted in rows. The *kharif* crop is usually sown with the single-tube *mogha* or *sadde*, one or two of which may be attached behind a plough or a blade-harrow, or a two-tyned furrow-opener. Occasionally, it is sown with a two-coultered seed drill, working in the wake of a blade-harrow. The *rabi* crop is almost always sown with a three-coultered, wooden seed drill. The practice of dibbling seed by hand has been adopted by many growers of American cotton. Shallow furrows are opened with a seed drill in a chess-board fashion at regular distances of two-and-a-half to three feet. Three or four seeds are sown by hand at each point of intersection of furrows. A handful of wellrotted farm yard manure is deposited with the seed, which is then covered by drawing a light *kunte* or blade-harrow over the sown field. For irrigated American cotton, the furrows (24 inches apart), are made in only one direction, i.e., across the slope of the land, and the seed is sown half way up the side of the furrow after a pre-sowing irrigation. Three or four seeds are sown by hand at successive distances of nine to twelve inches. No irrigation is given for a week or so, during which period germination is completed.

When the cotton is inter-cropped with groundnut or millet, one line of cotton is sown with a *sadde* after every two rows of groundnut or three to five rows of the cereal crop. The sowing of groundnut is done by a two-coultered drill and that of the cereal crop with a three or five-coultered implement.

As is the practice elsewhere, the seed is rubbed with a mixture of fresh cattle-dung and mud or ashes. To hasten germination, some cultivators (particularly of American cotton) soak the seed overnight in water and dry it in shade before treating it with the aforesaid mixture of dung and mud.

Depending upon the kind of seed drill used, the distance between the plant rows varies from 12 to 36 inches. The *mungari* crop and the American varieties, the plants of which usually make more vigorous growth, are given wider spacings. In areas of low rainfall, *desi* or *sannahatti* cotton is sown in rows spaced 18 inches apart. Plant growth in these tracts is not so good. The deficiency in yield is made up by the larger number of plants per unit area. In tracts of better rainfall, the inter-row spacing is increased to 24 inches. In the case of mixed sowings, the adjacent cotton rows are spaced three to five feet apart according as they are inter-cropped, with groundnut or millet.

The distance between plants in the row is not regulated for *desi* cottons. The rainfed sown crops of American cotton are often thinned to provide a plant to plant distance of six to eight inches. In the case of irrigated American cotton, and particularly of that sown in chess-board fashion, the crop is thinned to a stand of two plants per seed hole about four weeks after sowing.

The seed rate varies from 12 to 16 lb. (and sometimes 24 lb.) per acre in the Raichur Division, and 8 to 10 lb. in the Dharwar tract and Mysore plateau. In mixed cropping, the seed rate for cotton is reduced to about 6 lb. per acre. Drill-sown American cotton is planted with a seed rate of 10 to 14 lb. per acre, whereas the seed rate for its dibbled sowings is only 6 to 8 lb.

Weeding and Interculture. Due to a more thorough preparation of black soils for the growing of the *hingari* crop, the weed problem in the crop season is not very serious in their case. Retention of adequate soil moisture in the dry period after the rains is the *sine qua non* of the success of cotton growing on such lands. The crop on black soils is given one hand-weeding or is not weeded at all. It is harrowed with the *kolpa* or *yadde kunte* four to six times, depending on crop growth, the severity of the hot weather and the development of soil-fissures. The *mungari* crop on red soils is usually given one or two hand-weedings, followed by three or four bullock-hoeings. The inter-cultivation of rainfed American cotton is also similar. In row crops, the blade-harrow is worked between the rows, while in the crops sown chess-board fashion, the hoes are operated both ways, i.e., between the rows as well as between plants. If weeds grow thickly in any season, they are uprooted with a *desi* plough and removed before the cotton crop is given a bullock-hoeing. The hoeing continues as long as plant growth permits. It is continued longer in season of scanty rainfall. The irrigated crop is hand-weeded thoroughly after the first one or two irrigations. After every subsequent irrigation it is only harrowed until the plants cover the soil practically completely. Usually, six to eight irrigations are given in the whole season.

HARVESTING AND YIELD

The crops sown in the period from May to July flower in August-September and are harvested from October to December or January, whereas those sown in August-September begin flowering by the end of November or sometimes in December and are picked from February to April and sometimes in May. The irrigated American varieties, if sown in October, mature in the period from March to May, but when sown in February (as in the Irwin Canal area), they are harvested in July-August. In the latter case, the produce matures in the monsoon season and is, therefore, often damaged by the rains.

As in Andhra Pradesh, harvesting is completed in three or four pickings, the work being done by women and children. The wages of the harvesters, in a greater part of Raichur Division, are paid in kind as a fixed portion of the day's collection of produce. This agreed proportion varies with the quantity available on the plants for picking, being lower for the heavy mid-season pickings than for the relatively light, first or the end-season pickings. In the Dharwar Division, the crop is picked on a contract basis, the present rate being about 75 nP. per unit of 28 lb. of *kapas*. Except for the American varieties, the produce is usually picked with a lot of broken leaf and bracts. The former types have large bolls and, thus, permit comparatively clean picking.

The yield of the local varieties ranges between 250 and 350 lb. of *kapas* (seed cotton) per acre in the Transition tract of the Dharwar Division and in good black soil tracts of Chitaldrug and Shimoga districts. In the Raichur Division and, the comparatively dry, Eastern tract of the Dharwar Division, it is somewhat lower, varying from 200 to 250 lb. of *kapas* per acre, being more commonly near the lower figure. The short staple, *mungari* crop here also gives somewhat more yield than the *hingari* cotton.

The yield of rainfed American cotton is about 350 to 450 lb. of seed cotton per acre, the crop sown in May usually producing more than that sown later. In years of good, late rains, the early sown plants may produce a second flush of flowers, and give a considerably higher eventual yield. The dry American cotton sown in September-October, gives an average yield of 300 to 350 lb. of *kapas* per acre. Recent research at Dharwar and Gadag has shown that an earlier sowing of this cotton, say in the last week of July or early in August, increases the yield by 50 to 90 per cent. The feasibility of such advanced sowing in different parts of the Dharwar Division is now under investigation.

The irrigated American cotton sown in October gives an average yield of 700 to 800 lb. of *kapas* per acre. Crops sown in February in the Irwin Canal tract are said to give higher average yield. With adequate manuring and good cultivation both the early and the late sown crops produce considerably more, sometimes as much as 1,200 to 1,400 lb. of *kapas* per acre.

The disposal of cotton plants after completing the picking of produce is very similar to that in the neighbouring Andhra Pradesh. The grazing of plants is sometimes made conditional on the penning of sheep in the cotton fields. The plant stalks are largely used as fuel.

IMPROVED VARIETIES

Improved varieties, produced by the local Agricultural Department or imported from other States, are in cultivation on a large scale. Systematic crop improvement work for producing still more prolific, better spinning or otherwise superior types is in progress at several research stations under official *aegis*. The distinguishing characters and the distribution of the improved varieties at present recommended for cultivation are shown in Table 128.

Three other improved varieties have also been introduced into general cultivation, but each of them is still grown on only a small area. The varieties 881F and H.420 are recommended as substitutes for the inferior *mungari* variety, now in cultivation. Both the improved varieties are fit for spinning 20's to 24's warp counts as against 8's to 10's of the ordinary *mungari*, but they are late maturing, and the 881F is also relatively low ginning. The third variety namely, Madras-American, M.C.U.1, is recommended for irrigated cultivation in the Irwin Canal tract. This variety, under good conditions of cultivation, gives an average yield of about 800 to 1,000 lb. of *kapas* per acre. It has a ginning outturn of 35 per cent. staple length of 1-1/16″ and blow-room loss of about 8 per cent. It is fit for spinning 36's warp counts.

Laxmi cotton was primarily developed to replace another improved American variety, Gadag 1, which had been successfully brought into cultivation as the *hingari* crop on about 300 thousand acres of light black soil in the Kannada district of the former Bombay State. Gadag 1 was late maturing and highly susceptible to red leaf blight. Laxmi was evolved by crossing Gadag 1 with Co. 2 (a Madras Cambodia strain). It is not only early maturing but is also superior to Gadag 1 in yield, ginning outturn and spinning

TABLE 128. DESCRIPTION AND DISTRIBUTION OF IMPROVED VARIETIES OF MYSORE STATE

Variety	Species	Districts of cultivation	Statistical position		Characteristics						
			Annual area (thousand acres)	Production of lint (thousand bales of 392 lb.)	Average yield		Ginning outturn (per cent.)	Staple length (32nd inch)	Fibre weight per inch (millionth of an ounce)	Average mill spinning capacity (warp counts)	Blow-room loss (per cent.)
					Kapas (lb. per acre)	Lint (lb. per acre)					
Laxmi	*G. hirsutum*	Raichur Bellary Bijapur Belgaum Dharwar Chitaldrug Shimoga	1,172	178	300-350	100-120	33-36	28-30	0·134	30-32's	6
Mysore-American 5	*G. hirsutum*	Mandya Mysore Hassan Shimoga	42	16	350-600	120-200	33-35	33-34	0·138	30-32's	6
Jayadhar	*G. herbaceum* var. *frutescence*	Bijapur Belgaum Dharwar Chitaldrug	820	135	250-350	80-110	29-31	28-29	0·191	30's	10
Westerns 1	*G. herbaceum* var. *frutescence*	Bellary	220	40	200-250	60-70	28	26	0·195	24's	10-12
Selection 69	*G. herbaceum* var. *frutenscence*	Chitaldrug	15	6	250-300	70-90	28-30	24-26	0·180	20's	3-5

performance. Moreover, it is somewhat less susceptible to red leaf blight. It was accordingly released for general cultivation in 1950. Due to its special good qualities and high market price, it found very rapid favour with the growers of not only the former Bombay-Karnatak but also of the adjoining districts of Raichur and Gulbarga (former Hyderabad State), Chitaldrug (Mysore State), and Bellary, Cuddapah and Kurnool (former Madras State). The cultivation of Laxmi was taken up both under rainfed and irrigated conditions, on light black as well as red soils, in the *hingari* as well as the *mungari* seasons, and in tracts of low as well as moderately good rainfall. Not only this but Laxmi cotton also started displacing the *herbaceum* varieties Jayadhar, Westerns 1, Kumpta and Sannahatti, grown on heavy black soils in this region. Its area thus increased to about 1.2 million acres. This phenomenal but indiscriminate expansion led to the spread of blackarm and red leaf blight, to which this variety is susceptible, and also brought to light certain other serious defects. It has, therefore, been recommended to the cultivators to confine the growing of this variety, as far as possible, to the conditions of soil and season for which it had been originally evolved. At the same time, further crop improvement work has been taken up to produce varieties suited to different soil and seasonal conditions of the region and resistant to both blackarm and red leaf blight, but retaining the other distinctive characteristics of Laxmi (Plate XV).

Jayadhar (Plate XVI) is well suited to heavy black soils and is wilt-resistant. It is fairly prolific and possesses a distinctly higher ginning outturn than the varieties Jayawant and Kumpta, which it has wholly displaced. Selection 69, evolved by the Agricultural Department of the former Mysore State, is also fairly wilt-resistant.

MARKETING AND GINNING

The methods of marketing cotton in Mysore are not very different from those of Andhra Pradesh. The cultivators of Bidar, Gulbarga and Raichur districts sell cotton mostly as *kapas*. Small cultivators sell it to the village merchants, while the large land owners send it to the markets in the cities and towns. Some cultivators gin their crop at home by means of *charkha* gins, or get it ginned in the small ginning factories in the interior villages, retain the seed for sowing and/or feeding to cattle, and transport the lint for sale in large markets in their own or some other district. Thus, considerable quantity of lint from the Bidar district is marketed at Udgir and Latur in Bombay State, from Gulbarga district at the markets in Raichur district and from some parts of Raichur district in the markets at Adoni, Bellary and Gadag. The farmers of Bellary district usually sell their produce in the form of cotton lint while those of the Dharwar Division and the rest of the State market it as *kapas*.

Almost all the principal markets of the Raichur and Dharwar Divisions are regulated markets, the working of which is supervised and controlled by the market committees under the State's Agricultural Produce Markets Act.

These markets are well organised. The cultivators sell their cotton through *adatyas* or commission agents who attempt to obtain the highest price for their cotton and also help in a variety of other ways. In some markets of the Dharwar Division, there are farmers' sales co-operatives. The seed cotton delivered to the co-operative by each member cultivator is graded on the basis of staple length, ginning outturn, colour and cleanliness, and weighed by the society's staff. When a sufficient quantity has been thus collected, the pooled produce of each grade is auctioned publicly to the highest bidder. Samples of graded cotton offered for sale are shown to the bidders, but in the case of co-operatives of long standing, most of the traders accept the grading done by the society without examining the cotton. The highest bid in the auction is subject to the final approval of the chairman of the co-operative, who has the right to reject it as being too low and to hold the produce over for the next auction. Such graded produce sold by public auction over the past few years has fetched an average premium of Rs. 60 per *nag* of 1,344 lb. of *kapas* for Laxmi cotton and about Rs. 25 per *nag* for Jayadhar. This method has become popular with both the growers and the manufacturers of cotton. Whereas it has helped the grower to receive the intrinsic price for this produce, it has enabled the mill buyer to purchase pure, high grade cotton in bulk from dependable sources. This system has also helped in the maintenance of the purity of improved varieties introduced by the Agriculture Department. Cotton produced by the registered seed growers of the Reserved Area, from pure seed of successive generations, supplied by the Agricultural Department, is graded and auctioned by the departmental staff after due scrutiny. The sale in such cases is made on the condition that the graded produce will be ginned under official supervision and the Agricultural Department will be given the first option on the purchase of the resulting pure seed.

Adequate ginning facilities exist in almost all cotton-growing districts. Besides the large ginning factories in the principal market towns, small ginneries, each having 4 to 8 gins, operate in many interior localities. Platt's single-roller or double-roller gins seem to be in equal favour. The pressing establishments are not equally adequate. Loose cotton lint has, therefore, to be transported long distances in several tracts for being pressed into exportable bales. Thus, while ginning factories for growers of the Raichur district are available at Raichur, Kopbal, Gangawati, Manvi, Sindhnur, Deodrug, Kushtagi, Maski, Karatgi and a few other places, pressing facilities within the district are available at Raichur and Kopbal only, the distance between the two places, being over 100 miles. Considerable quantities of ginned cotton of this district are carried to Gadag in the Dharwar district and Adoni and Bellary in the Bellary district for pressing. The same is the case with many other areas. The pressing machinery is invariably of the hydraulic type.

The ginning charges are fixed on the basis of a unit weight of lint. For instance, the prevailing rate in many parts of the Dharwar Division is Rs. 12 per *nag* of lint weighing 336 lb. Since the gins in several localities are in excess of actual requirements, their owners combine to form a pool under which some factories are kept idle in the season but their owners share in the net profits of the working ginneries on the basis of the number of gins in each factory.

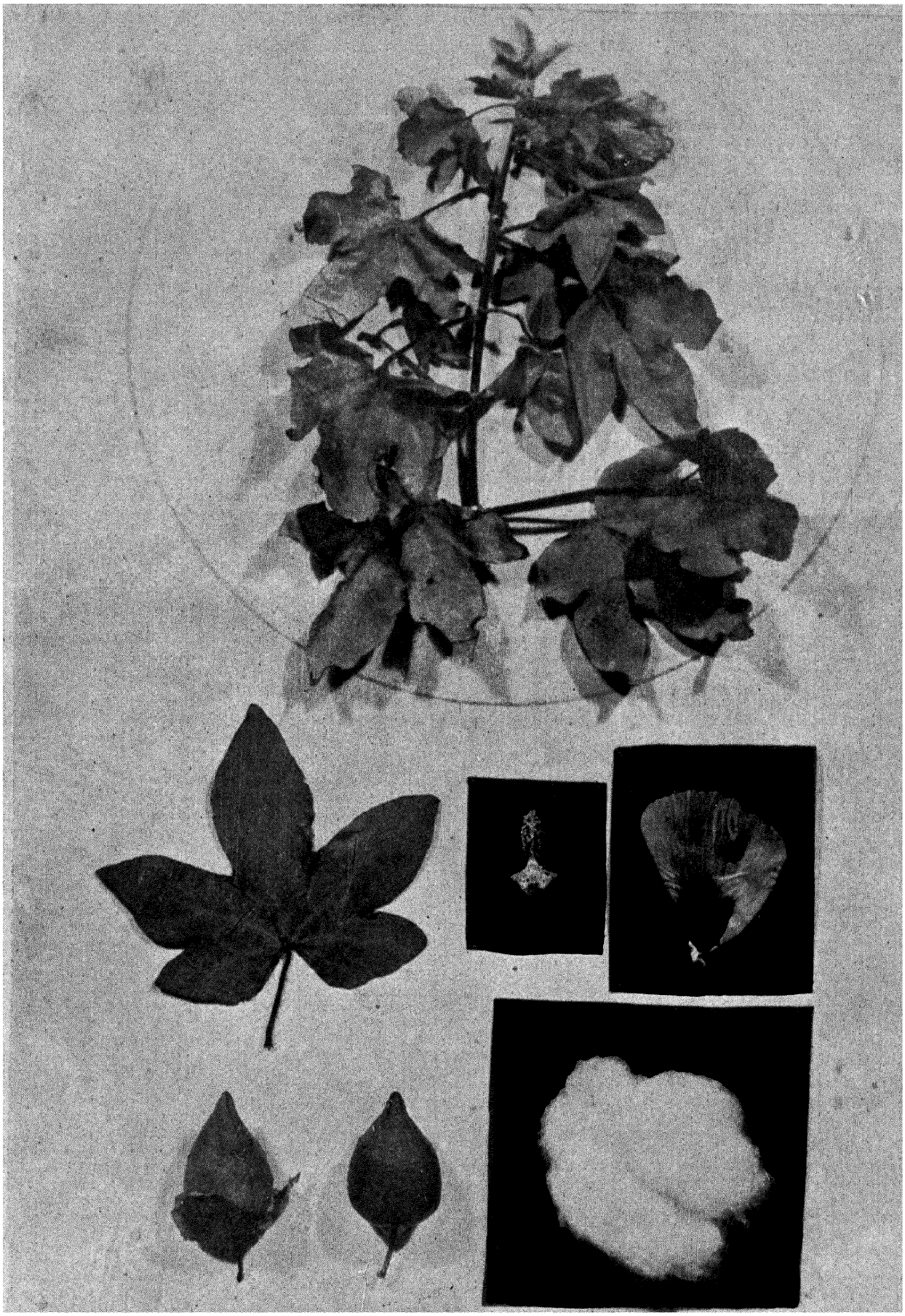
The pressing charges are levied on the basis of a bale of lint weighing 392 lb. net. Both the ginning and pressing charges were until recently subject to ceiling fixed annually by the Central Government. The distribution of coal and steel hoops to the ginning and pressing factories is also regulated by the Government of India through the agency of the Indian Central Cotton Committee.

With the large-scale cultivation of improved varieties in more or less compact areas, the supervision exercised by the market committees and Agricultural Department on the marketing of cotton and its processing by ginning and pressing factories and, the vigilance exercised by the textile mills themselves, malpractices, such as watering, mixing, faulty ginning and false packing, which were very common a few years ago, are now very rare. The penalties prescribed by the Ginning and Pressing Factories Act against such malpractices have also had a deterrent effect.

PESTS AND DISEASES

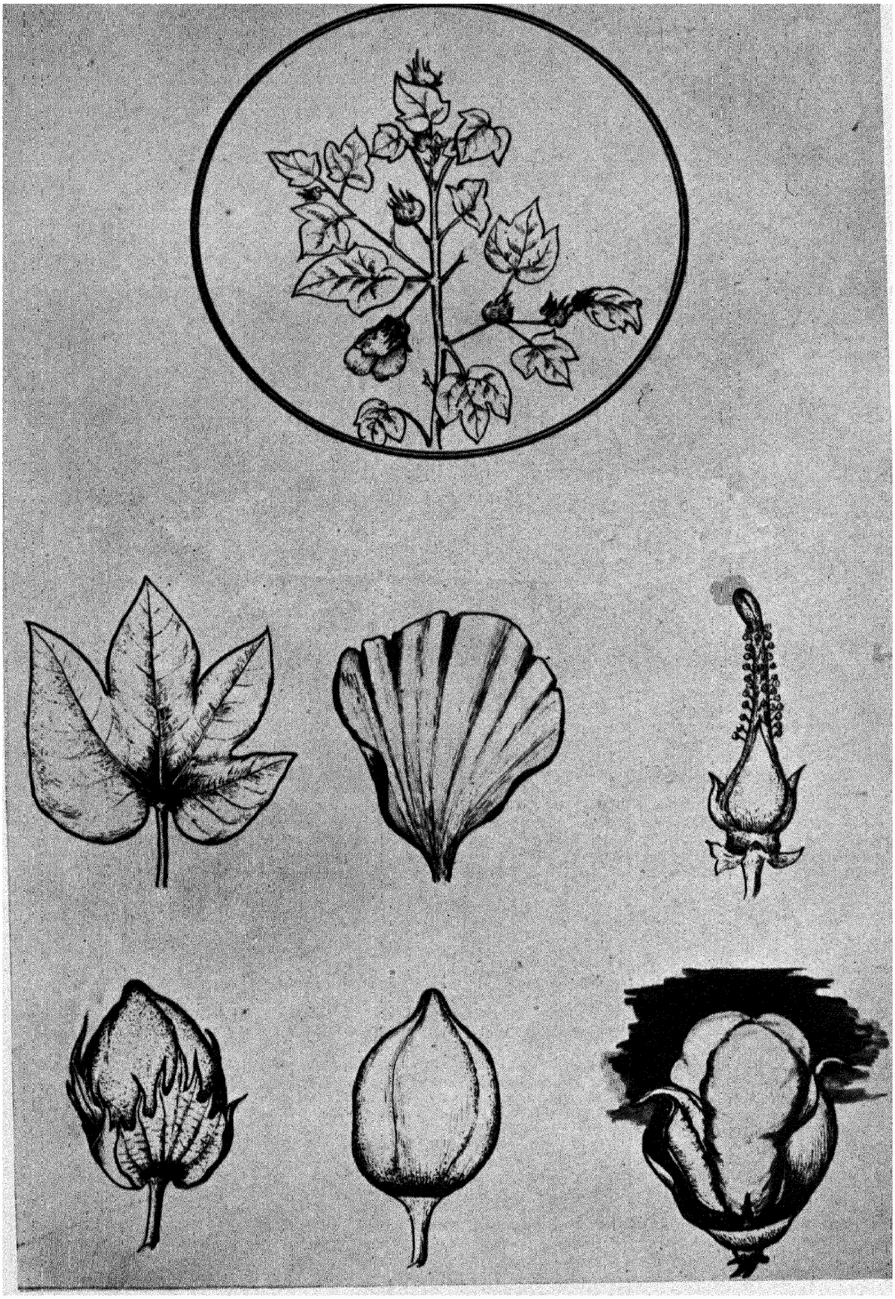
Insects causing the greatest damage to the cotton crop in Mysore are pink bollworm (*Platyedra gossypiella* S.) and spotted bollworm (*Earias* sp.). Their gravity as pests and the control measures against them are similar to those mentioned for Andhra Pradesh. Jassid is another important pest of American varieties. The cultivation of resistant varieties, such as Laxmi, Cambodia and Mysore-American 5, has considerably reduced its importance. Leaf-roller also causes serious damage to American cotton in some years. The stem weevil (*Pempherulus affinis* Fst.) attacks the Combodia varieties in some areas. The compulsory removal of cotton plants before the 1st August has been prescribed as a control measure in Madras State, but where cotton is under cultivation practically throughout the year, the pest is not deprived of food and this control measure is not really effective. Thrips and aphis are minor pests.

The most common disease is cotton wilt (*Fusarium vasinfectum* Atk.). It is a disease of the Asiatic varieties, American cotton being immune. Before the introduction of wilt-resistant varieties, it used to cause a loss of 40 to 70 per cent. in some parts of the Dharwar Division. The production of Jayawant, and then Jayadhar, as wilt-resistant varieties has almost completely controlled the disease. The Selection 69 also is fairly wilt-resistant. Root rot (*Macrophomena phaseoli*) is another disease doing sometimes serious damage to both Asiatic and American varieties in the Eastern tract of the Dharwar Division in the early part of the cotton season. No resistant cotton variety or effective

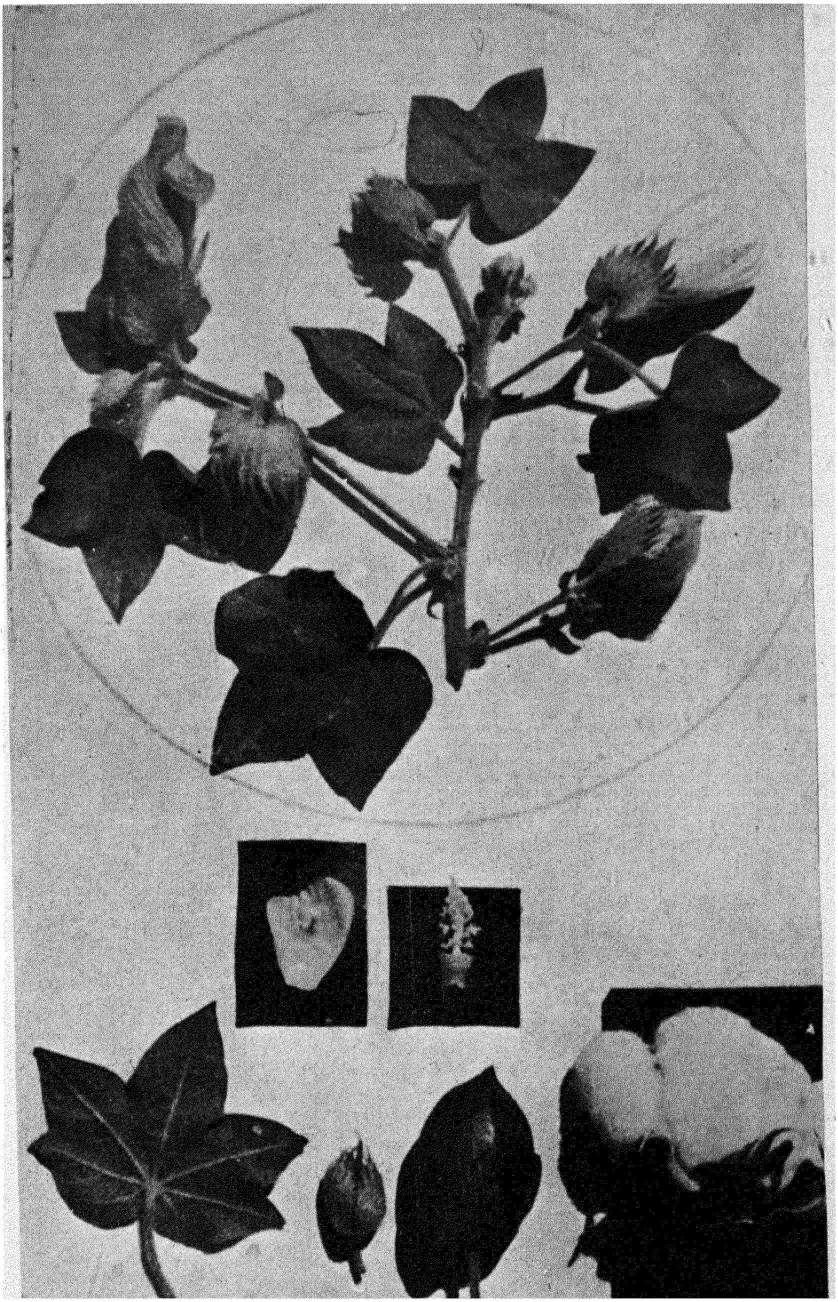


Characteristics of Gaorani 6 Cotton Plant

PLATE XIV

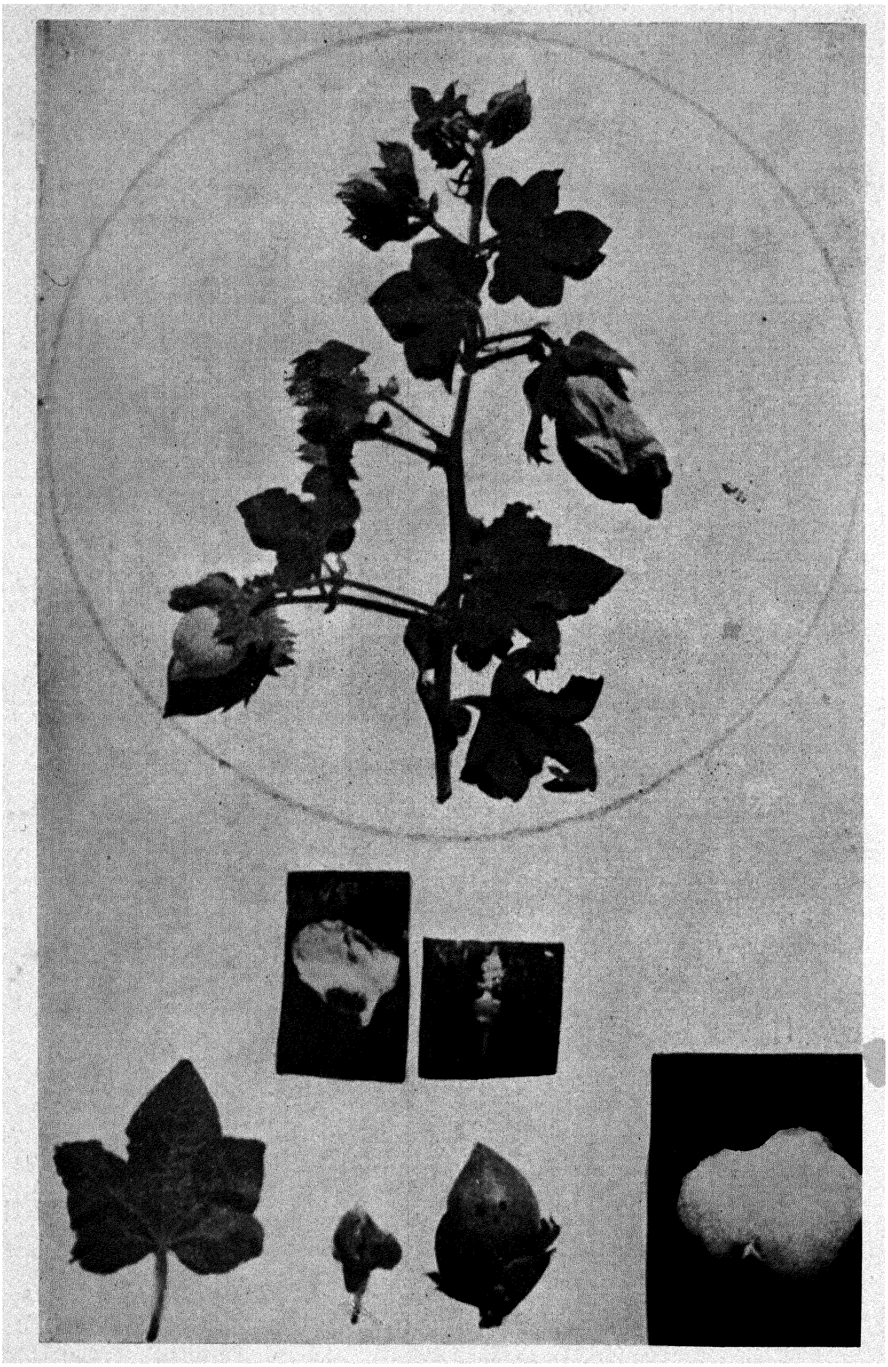


Characteristics of Myspre-American 5 Cotton Plant



Characteristics of Laxmi Cotton Plant

PLATE XVI



Characteristics of Jayadhar Cotton Plant control measure for this disease has been found so far. Two other diseases of importance in Mysore, as in Andhra Pradesh, are the virus disease stenosis or small leaf and the physiological disease red leaf blight. The former attacks the Asiatic varieties, whereas the latter affects cheifly the American types, like Gadag 1. No method of control is known for stenosis. When red leaf blight is associated with jassids, dusting with sulphur has been found to afford relief. The improved variety, Laxmi, is less susceptible to red leaf blight. Yet another disease, namely blackarm, has assumed importance in recent years with the indiscriminate expansion of the cultivation of Laxmi cotton. This variety, otherwise highly desirable, is susceptible to blackarm. The disease has become so widespread in the Dharwar Division and some parts of Raichur and Chitaldrug districts that a special crop improvement scheme has been started to produce a blackarm-resistant variety to take the place of Laxmi cotton. Initial results are encouraging.

ECONOMICS OF PRODUCTION

Cotton is one of the principal cash crops of the Raichur and Dharwar Divisions. In the rest of the State, it is not of major importance except in Chitaldrug and some parts of Hassan district. The area under cotton in this part of the State does not exceed 1,00,000 acres out of the annual cultivated area of about six million acres.

No reliable data on the economics of cotton production are available for the Raichur Division as a whole. The figures (Table 129) of the labour requirements of the crops together with those of the cost of cultivation and income under irrigated and unirrigated conditions have been furnished by the Assistant Cotton Specialist, Siruguppa (Bellary district) and are given for what they are worth. The figures for irrigated cultivation pertain to Laxmi cotton, which is a high-priced American variety, whereas those of dry land crop are for Westerns 1, which is a *herbaceum* type. Moreover, the data for irrigated cultivation are said to be the average of three seasons only as compared with the average of five seasons in the case of dry land cultivation.

In the absence of basic information on the method of collecting data, wages paid to labour, yields harvested per acre, and the ruling market prices for the two varieties, it is not possible to say how far the figures given are truly representative. It is also not known whether the data pertain to the Government Farm crops or the crops of the ordinary cultivator, and whether the figures are for a comparable period of time.

Another estimate of the economics of production of Jayadhar (*herbaceum*) cotton grown in the Dharwar Division is given in Table 130. This has been taken from a note prepared by Sarvashri G. B. Patel and P. S. Pandya.

With the average yield of 250 lb. of *kapas* per acre and *kapas* selling at Rs. 525 per *nag* of 1344 lb., the gross income from cultivation of Jayadhar

TABLE 129. LABOUR REQUIREMENTS, COST OF CULTIVATION AND INCOME PER ACRE

a. Labour Requirements of Crop per Acre

Particulars	Irrigated cultivation			Dry land cultivation		
	Cattle (pairs)	Men	Women	Cattle (pairs)	Men	Women
Preparatory cultivation	9	16	—	1	1	—
Manures and manuring	6	6	10	½	½	¼
Seeds and sowing	—	—	10	½	½	½
After cultivation	2½	7½	31	½	½	4¼
Irrigation and drainage	—	5	—	—	—	—
Harvesting	—	—	32	—	—	16
	17½	34½	83	2½	2½	21

b. Cost of Cultivation and Income per Acre

Particulars	Irrigated cultivation (Laxmi)	Dry land cultivation (Westerns 1)
	Rs.	Rs.
Total cost of cultivation per acre	191·81	30·37
Gross value of the produce realised	451·94	81·37
Net profit	260·13	51·00

TABLE 130. ECONOMICS OF PRODUCTION OF JAYADHAR COTTON GROWN IN DHARWAR DIVISION

Item of cultivation	Labour units			Cost per acre (Rs.)
	Bullocks	Men	Women	
Ploughing	4‡	2	—	8·00
Harrowing (4)	4	2	—	8·00
Manuring*	—	—	—	10·00
Cost of seed (10 lb.)	—	—	—	1·25
Sowing and covering	2	1	1½	4·94
Intèr-culturing (4)	2	2	—	5·00
Weeding (3)	—	—	12	7·50
Harvesting (250 lb. *kapas*)*	—	—	—	6·75
Land assessment	—	—	—	5·00
Interest on outlay	—	—	—	5·00
Total	12	7	13½	61·44

‡ The charge for hiring one pair of bullocks with one attendent is Rs. 4 per day and the daily wage of a woman labourer is Re. 0·62.

* Cotton is not manured directly. Preceding *jowar* crop is usually manured at five cart loads of farm yard manure per acre. Fifty per cent. of the cost is accordingly debited to cotton.

† At Rs. 5 per maund of 40 lb.

** Picking charges paid at Re. 0·75 per maund of 28 lb. of *kapas*.

cotton works out to Rs. 96.75 per acre and the net income Rs. 35.31 or about Rs. 35 per acre. In view of the greater yield and highest market price of Laxmi cotton, the net income from the cultivation of this American variety would be appreciably more. The rapid popularity which this variety has earned with the farmers of almost all parts of this region is proof of its cultivation being more profitable.

SEED MULTIPLICATION AND DISTRIBUTION

The multiplication and distribution of pure seed of the improved varieties, Laxmi and Jayadhar, is carried out systematically under a special scheme operated in the Dharwar Division. The scheme was originally financed jointly by the Indian Central Cotton Committee and the Government of former Bombay State, but in 1954 it was placed on a self-supporting basis. The scheme provides for the multiplication of pure seed in six successive stages. The crop of the First Stage, is grown at a Government Farm from the selfed seed supplied by the Cotton Breeder of the State Agricultural Department. The crop is examined in the field by the Cotton Breeder and his technical assistants and all off-type plants, if any, are pulled out. The produce of the remaining plants (which are true to type) is harvested and ginned under close official supervision to maintain purity. The seed obtained from this First Stage crop is multiplied in the following season either at a Government Farm or on the private estates of one or more registered seed growers, who cultivate their crops and gin the produce under the control and supervision of the Cotton Breeder. This crop also is examined in the field for removal of off-type plants soon after or before the commencement of flower-formation. The seed from the Second Stage crop is purchased and supplied to the Cotton Superintendent at Dharwar, who is an extension officer responsible for the gradually increasing multiplication of pure seed in the four succeeding stages. This work is done with the co-operation of four separate groups of registered seed growers. The first group receives the seed from the Government Farm and plants it under the supervision of the Cotton Superintendent, whose assistants inspect the standing crop in due course to remove any off-type plants that may appear. After the cotton is harvested, it is sold through an approved agent (which may be a co-operative society or an individual merchant) to a buyer who agrees to gin the produce separately under official supervision and sell the seed to the Agricultural Department for supply to the next group of registered seed growers for further multiplication. The Agricultural Department usually purchases the pure seed of different stages at a premium of 5 to 10 per cent. over the ruling market price of ordinary seed of the same variety. The second group of registered seed growers multiplies the seed obtained from the first group, the third group from the second, and the fourth group from the third. The seed of different stages is multiplied in more or less compact blocks to facilitate supervision and to prevent admixture.

The area covered at each stage is generally so fixed that the seed produced by the fourth group of registered growers is sufficient for sowing at least 50 per cent. of the area for which a particular variety is deemed suitable. The extension of cultivation of the improved variety to the remaining area is assumed to take place by natural spread. The seed cotton produced by the different groups of registered growers is pooled stage-wise, graded into two or three classes and sold by public auction as described earlier. The seed of Third, Fourth, Fifth and Sixth Stages is purchased, stocked and distributed according to stages with the help of the sales co-operatives or the approved individual merchants. From 4½ to 5 million pounds of pure seed of each of the two improved varieties is distributed annually to plant 400 to 500 thousand acres of the respective Reserved Area.

Somewhat similar arrangements exist for the production and supply of the pure seed of Mysore-American 2 and Selection 69 in Bangalore and Mysore Divisions, and of Westerns 1 in the Raichur Division. The seed of Laxmi and Jayadhar varieties, needed for the Raichur Division, is obtained at present from Dharwar, but a scheme for the local production of this seed is under the active consideration of the State Government and the Indian Central Cotton Committee.

The total area in which improved cotton varieties were grown in the State in 1955-56 was as follows :

Variety		Area (thousand acres)
Laxmi		1,172
Jayadhar		834
Mysore-American 5		42
Westerns 1		200
Selection 69		15
	Total	2,263

The area of 2.263 million acres covered by the improved varieties in 1955-56 constituted 80.1 per cent. of the total area under cotton in the State.

UTILIZATION OF COTTON SEED

The average annual production of cotton seed is about 1,18,000 tons. About 10 per cent. of this quantity is used for purposes of sowing and 20 to 30 per cent. is consumed as feed for working and milch cattle. Except in Bellary where the cultivators retain their seed for planting and cattle feed, the bulk of the seed produced in the State goes to local or outside oil mills for crushing purposes. Cotton seed oil is partly used as such for industrial purposes and partly hydrogenated for culinary use.

COTTON LEGISLATION

Regulated Cotton Markets. For an orderly and remunerative marketing of cotton (and other agricultural produce), all the prinicpal cotton marketing centres in the State are now working as regulated markets under the provisions of the Agricultural Markets Act of the former States of Bombay, Hyderabad, Andhra Pradesh or Mysore, in which they were originally located. The price of the produce brought for sale is determined according to variety and grade by public auction. The licensing of merchants, commission agents and weighmen, the fixation of permissible trade allowances, and the use of weights and measures are governed by the provisions of the relevant Acts.

Cotton Protected 'Areas. For maintaining the purity of cotton grown in the Dharwar Division, this tract is divided into the following three zones, each of which forms a protected area under the Cotton Transport Act, 1923 : (*i*) Kumpta-Dharwar Protected Area, consisting of Dharwar and Belgaum districts; (*ii*) Bagalkot Protected Area, consisting of Bagalkot, Hungund and Badami *talukas* and Bilgi Petha of Bijapur district; and (*iii*) Bijapur Protected Area, consisting of Bijapur, Indi, Sindgi, Bagewadi and Muddebihal *talukas* of Bijapur district.

The movement of cotton lint, cotton seed and *kapas* from one protected area into another and also from outside areas into any of these protected areas is prohibited under the provisions of this Act. To prevent illicit movement, nine permanent cotton check stations have been established at suitable points of the periphery of the protected areas. In addition, 41 temporary check stations are set up annually during the cotton marketing season from February to July.

In the Raichur Division, a portion of Bellary district, growing Northerns and Westerns cottons, formed part of a protected area constituted for these varieties by the former composite State of Madras. The question of continuing it as a protected area is under the consideration of the Government of re-organised Mysore State.

Similarly a part of Raichur district forms another protected area under the name Raichur Protected Area. It consists of the tract lying to the west of the metalled road starting from Gangawati in the south, passing through Lingsugar and terminating at the bank of river Krishna in the north. This protected area is constituted under the Hyderabad Cotton Cultivation and Transport Act (No. VI of 1337F.) and grows pure crops of Jayadhar and Laxmi cottons.

Compulsory Cultivation of Improved Varieties. Under the Cotton Control Act (1942) of the former Bombay State, the varieties Jayadhar and Laxmi were notified as the only approved varieties for the Dharwar Division. The cultivation, possession of, and dealing in varieties other than those approved by the State Agricultural Department were strictly prohibited. This arrangement is being continued by the new Mysore State.

Control of Cotton Ginning and Pressing Factories. The working of Cotton Ginning and Pressing Factories is controlled and regulated in Raichur, Gulbarga and Bidar districts by Section 63 of the Hyderabad Factories Act (No. IV of 1337 F.), and in Dharwar, Belgaum and Bijapur districts by the Cotton Ginning and Pressing Factories Act, 1925. The question of licensing of gins and presses and of preventing watering, mixing and other malpractices in the remainder of the State is under consideration by the Government.

CHAPTER V

WESTERN *HERBACEUM* REGION

INTRODUCTION

The varieties of cotton at present grown in India belong to the species *Gossypium arboreum*, *Gossypium herbaceum* and *Gossypium hirsutum*, the former two being of the Asiatic or the Old World group of cottons and the latter, of the American or the New World group of cottons.

In the ancient literature of India, while there are references to the use of cotton for making the sacred thread of the Brahmins and for weaving of cloth, there is no description, surprisingly enough, of the plant itself. Theophrastus (350 B.C.) gives us (Watt, 1907) the first definite conception of Indian cotton cultivation. He says that the trees from which the Indians make clothes have a leaf like that of the mulberry, but the whole plant resembles the dog-rose. They set them in the plains, arranged in rows so as to look like vines from a distance. In the 'Periplus of the Erythraean Sea' (63 A.D.), we have the first commercial mention of Indian cotton. The raw fibres, as also the Indian cotton manufactures, were conveyed by the Arabs from Patiala, Ariake and Barygaza (the modern Broach) up the Red Sea to Aduli. According to Watt (1907), "Rashi-ud-din (Jamiu-t Tawarikh, 1310 A.D.) who compiled largely from Al Biruni (who lived from 970 to 1039), speaks of the cotton plants of Gujerat growing like willows and plane trees, and yielding produce ten years running." Marcopolo (who travelled through a large portion of Asia in 1290 A.D.) refers to the production and manufacture of cotton in Persia, Kashgar, Yarkand, Khotan, Gujerat, Cambay, Telengana, Malabar, Bengal, etc. Speaking of Gujerat he says that the cotton trees are of great size and attain an age of 20 years, but he adds, when of that age, the cotton is only used in quilts or to stuff beds. Rev. E. Terry (Watt, 1907), Chaplain to Sir Thomas Roe's Embassy to India in 1615, speaks of the cotton plants near Surat as growing for three or four years before being uprooted.

This account shows that the cotton plants in question were of a perennial—and not annual—growth habit. In fact, even to the present day, we find the perennial variety Rozi (*G. arboreum* race *indicum*) being grown along with *bajra* (*Pennisetum typhoidum*) in stray fields in middle Gujerat and is found to persist naturally in hedges from the north of Baroda right up to Kutch, an arid region characterised by deep, sandy *gorat* soils. This Rozi variety is found to be conspicuously absent in the deep black soil areas of Surat and Broach districts of Gujerat. The other perennial cotton belonging to *G. arboreum* species is the red-flowered Narma cotton or Dev Kapas which is never grown as a field crop but exists as stray plants in temple compounds or back yards. This would indicate that the cotton plants referred to by early writers belonged to *G. arboreum* species. However, the varieties of cotton at present grown in Gujerat exclusively belong to *G. herbaceum* species with the exception of the two *arboreum* varieties already referred to and with the exception of Mathio cotton (*G. arboreum* race *indicum*) grown in southern Kathiawar, which was recently introduced from Khandesh after the great famine of 1900. With these exceptions, the whole of Gujerat, including Saurashtra and Kutch, is homogeneous for *G. herbaceum* species of cotton now being grown there. The earlier description of the perennial cotton grown in Gujerat, the restricted distribution of *G. herbaceum* to a belt of country fringing the West Coast of India, the limited degree of variability of botanical characters, as compared to that in *G. arboreum*, all indicate that *G. herbaceum* is not endemic to India. Zaitzev (1928), by examining the forms occupying Indo-China and Africa, concluded that *herbaceum* were of African origin. How and when these cottons were introduced in Gujerat is not known. The first evidence to indicate that Gujerat cottons differed from other cottons grown in India was supplied by Taylor. He reported that prior to 1783, Surat cottons were imported into Bengal and that they differed, from *desi* variety, in being easy ginners. Since *herbaceum* can be more easily ginned than *arboreum*, it is probable that Surat cottons referred to by Taylor were of *herbaceum* type. Hove, in 1787, (Watt, 1907) alludes to three types, of which red and yellow-flowered perennials can be taken as *arboreums*. The third type, an annual one, was possibly a *herbaceum*. In the report of the Proceedings of the East India Company (1812), a statement has been made by the Governor of Bombay that Surat cotton is an annual and of the black-seeded type (in contrast to the green-seeded types produced by the *arboreum*). Considering the differences in the descriptions of cotton given by Terry in 1615, and by Hove in 1787, it is possible that the spread of *herbaceums* in Gujerat may have taken place between 1615 and 1780 (Ramanathan, 1936). Yet another homogeneous tract growing *G. herbaceum* cotton is the black soil areas of the Bombay-Karnatak. The variety is known by the name Kumpta, so named after the Kumpta Port wherefrom it was exported. It is also known as *jowari-hatti* or *desi* cotton to distinguish it from the American cotton which was introduced much later and which by itself is known as *vilayati-hatti*. There is no mention of Kumpta or *jowari-hatti* cotton in the earlier accounts of travellers in the Karnatak. It is possible that it was introduced from Gujerat regions growing open boll forms of *G. herbaceum*. By itself, the variety shows less variability than Gujerat *herbaceums*. Other varieties of *G. herbaceum* grown in South India go under the name of Uppam, Hagari and Westerns, which are sympodial in growth habit (in contrast to the monopodial growth habit of Gujerat *herbaceums*), a character modification occurring due to climatic and other growth conditions. Otherwise, these in themselves also show lesser variability than Gujerat *herbaceums*. There is reason to believe that the origin of these varieties is *G. herbaceum* cotton grown in Dharwar and Chitaldrug districts of the Karnatak, from where it was taken to South India (Ramanathan, 1936).

The varieties of *G. herbaceum* are generally characterised by lighter green foliage, broad, rounded leaf lobes with constricted base, broad serrated bracteoles, flaring at maturity, and bolls almost parallel-sided with prominent shoulders or rounded, the boll surface being generally smooth with few and inconspicuous glands and bolls, opening widely or very slightly at maturity. In contrast to the varieties of *G. arboreum*, forms with deeply cut leaves and with red or white flowers are not known in *G. herbaceum*, while forms with close or slightly opening bolls are not known to occur in *G. arboreum*. The principal varieties of *G. herbaceum* cotton that were being grown in the Western *herbaceum* Region are: (*i*) Surti-Broach or Lalio (so named on account of the cotton hanging in a pendular manner in the ripe boll); (*ii*) Goghari; (*iii*) Wagad (also named as *dhumad-sakalio*, meaning cotton with shell, or *dabalio*, meaning cotton enclosed in a shell or *dabali*) in Gujerat, including Saurashtra and Kutch; and (*iv*) Kumpta in the Bombay-Karnatak. These varieties possess special differentiating characteristics. Surti-Broach variety is characterised by bushy monopodial habit of growth. The whole plant is generally hairy, the young leaves and bracteoles pubescent. The lower and larger leaves have between five and seven lobes, the upper leaves three to five, half or less than half, segmented. The middle lobe is ovate, acute, mucronate and constricted at the base. The stipules are persistent, linear, and those in peduncles markedly unequal, one of them oblique, secondary or tertiary ovate, truncate, toothed and the other lanceolate acuminate. The bolls are not normally so smooth; are smaller, tipped, parallel-sided, and humped, usually three-locked, seldom two or four-locked, opening fully when ripe, the valves being highly recurved on the edges. The lint adheres loosely to the seed. The ginning outturn is about 33 per cent. and staple about 7/8", smooth and fine. The seeds are smaller than in Wagad cotton and covered with whitish fuzz, usually six to seven per lock.

Goghari variety differs from Surti-Broach in having somewhat broader leaf lobes. The foliage in some types is more pubescent. The bolls are generally roundish and bigger. The chief distinguishing characters are that the segments of the capsules are broader and do not recurve when ripe. As a result, the boll opening is not so fully wide as in Surti-Broach variety. In Goghari variety, while pulling the locks, the lint hairs surrounding each seed separate readily from those of the adjoining seeds and the seeds do not, therefore, cling together by means of the lint hairs in the manner which is characteristic of Surti-Broach cotton. This difference is due to the lint hairs in Goghari variety being shorter and thicker than in Surti-Broach. In Goghari variety the lint adheres more firmly to the seed, and it is thus not so easy to gin as Surti-Broach. The seeds present darker appearance on account of their being less fuzzy. The ginning outturn is very high (40 to 45 per cent. and in some strains up to 50 per cent.). The lint is whiter but the staple is short (5/8") and coarse. There is no definite information about the origin of the variety. Its name would suggest that it was originally brought from Gogha, a port in Saurashtra to the south of Bhavnagar and from there across the Gulf of Cambay to Jambusar *taluka* of Broach district, where it was being grown in a pure form. Whether the variety was introduced independently of Surti-Broach, occurring as a wide open boll variant of the close boll variety Wagad, or arose through hybridisation between Surti-Broach (Lalio of North Gujerat and Saurashtra) and Wagad, cannot be definitely said, though in artificial crosses between these two varieties, very high ginning forms (surpassing the high ginning Wagad variety) resembling Goghari variety have been secured (Patel, S. J., Unpublished).

Wagad variety is characterised by dense habit of growth due to shorter internodes and due to the monopodia (which are comparatively few in number) developing at lower internodes than in Surti-Broach or Goghari varieties. The plants are less hairy. The young stems, petioles, etc., are thickly covered with simple hairs. Stellate hairs are numerous on the young leaves and few on the older leaves which appear almost glabrous and leathery and have a shining oily appearance. The leaves have between three and five lobes and are cordate, half segmented or less. The lobes are ovate to broad ovate, constricted at the base; the lobes of the leaves on the younger branches are broad, obtuse and not constricted at the base. The spreading habit of the bracteoles is most marked in this variety. The flowering is earlier than in Surti-Broach variety, but the ripening is slow. The bolls are smooth, globose usually, but sometimes tapering, mostly three-celled. Four-celled bolls are not, however, uncommon. The most characteristic feature of the variety is that the bolls, when ripe, open only slightly and do not fall off but adhere firmly to the plant. The bolls are, therefore, reaped in one or two lots when the crop is ripe and the seed cotton is extracted by hand by forcing open the shells. The ginning outturn is fairly high (about 35 per cent.). The lint is dull white and coarse and the staple somewhat shorter than in Surti-Broach variety. The seeds are usually large in size, fuzzy and have a distinct hook at the tip. They are usually found to be five to eight per lock. The variety is hardy and tolerates saltish soil conditions. No information is available as to the origin of this variety and how its cultivation got established in Kutch, Saurashtra and North Gujerat. Possibly, it takes its name either from a tract known as Wagad in the eastern part of Kutch or from a group of villages with this name in Dhandhuka *taluka* of Ahmedabad district. Whether either of these represent the locality where it was originally grown, or whether it was introduced from outside, cannot be said with certainty.

Kumpta cotton of the Bombay-Karnatak, while closely allied with

Madras or South Indian *herbaceum* cottons, in several particulars, markedly differs from Gujerat *herbaceum* cottons, viz., Surti-Broach or Lalio and Goghari. Gujerat *herbaceums* are characterised by bushy growth, producing a number of vigorous monopodia while Kumpta cotton is more erect and open in the growth habit, producing a very limited number of monopodia. The stem and the branches are comparatively thinner, and the leaves are also smaller. Kumpta cotton shows early drying up of the lower leaves at the beginning of the cold season, which is not the case with Gujerat *herbaceums*. The period of growth is shorter by about two months in Kumpta cotton. Gujerat *herbaceum* cottons are usually planted in June, while Kumpta cotton is sown in August-September, but the crop is obtained by about the same time in February-March. Kumpta cotton has much smaller bolls and much lower ginning percentage, the latter being only about 25 per cent. The colour of Kumpta cotton is dull with a tinge of brown in it, while Gujerat *herbaceum* cottons are creamy or white and bright in colour. The staple is about 7/8". The seeds of Kumpta cotton are much smaller and less covered with fuzz.

The varieties of *G. herbaceum* cotton grown in India were until recently commercially known as Surti or Surti-Broach, Kanmi, Dholleras, Wagad or Kalagin (bolls opening only slightly at maturity), Kumpta and Westerns (Uppam and Hagari).

AREA AND PRODUCTION

Out of the total area of 1,83,46,000 acres (during 1954-55 season) grown under cotton in India, 46,07,000 acres (or 25 per cent. of the area) was under *G. herbaceum* cotton, producing about 12,37,000 bales (392 lb. each) of lint. This was about 30 per cent. of the total production, of the value of nearly Rs. 50 crores.

Statistics of area and production of cotton in different States of the Region are shown in Figures 29 and 30, while those for the First and Second Five-Year Plan periods are given in Figure 31.

The group of *herbaceum* cottons is, however, particularly important in India as it largely contributes to medium and long staple group of cottons produced in the country.

Staple-wise production of cotton for the Western *herbaceum* Region is shown in Figure 32.

Considering the soil, varietal and climatic complex, the Western *herbaceum* Region can be divided into the following four sub-regions or tracts.

South Gujerat Tract	—	The cotton-growing area of Gujerat and part of Khandesh, south of the river Narmada, at present growing Vijalpa (2087) improved variety of cotton.
Middle Gujerat Tract	—	The cotton-growing area of Gujerat, between the rivers Narmada and Sabar-

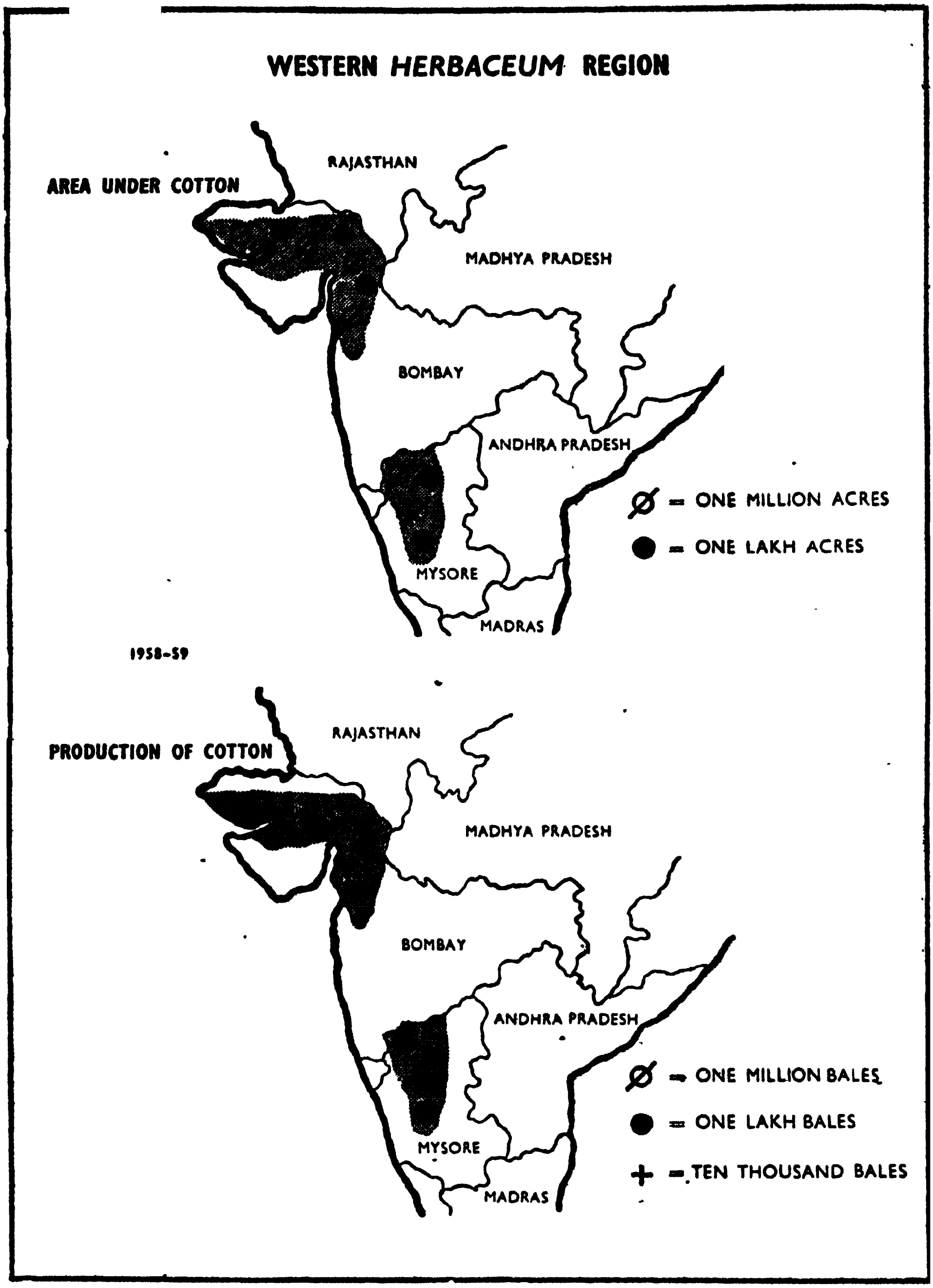


Fig. 29. Intensity of Area and Production of Cotton in the Western *herbaceum* Region—1958-59

mati, at present growing the improved variety Broach-Vijay or Digvijay.

North Gujerat Tract including North Saurashtra and Kutch — The cotton-growing area of North Gujerat, North Saurshtra and Kutch at present growing the improved variety Kalyan or Wagad.

Kumpta Cotton Tract of the Bombay-Karnatak — The cotton-growing area of the Bombay-Karnatak, at present growing the improved variety Jayadhar.

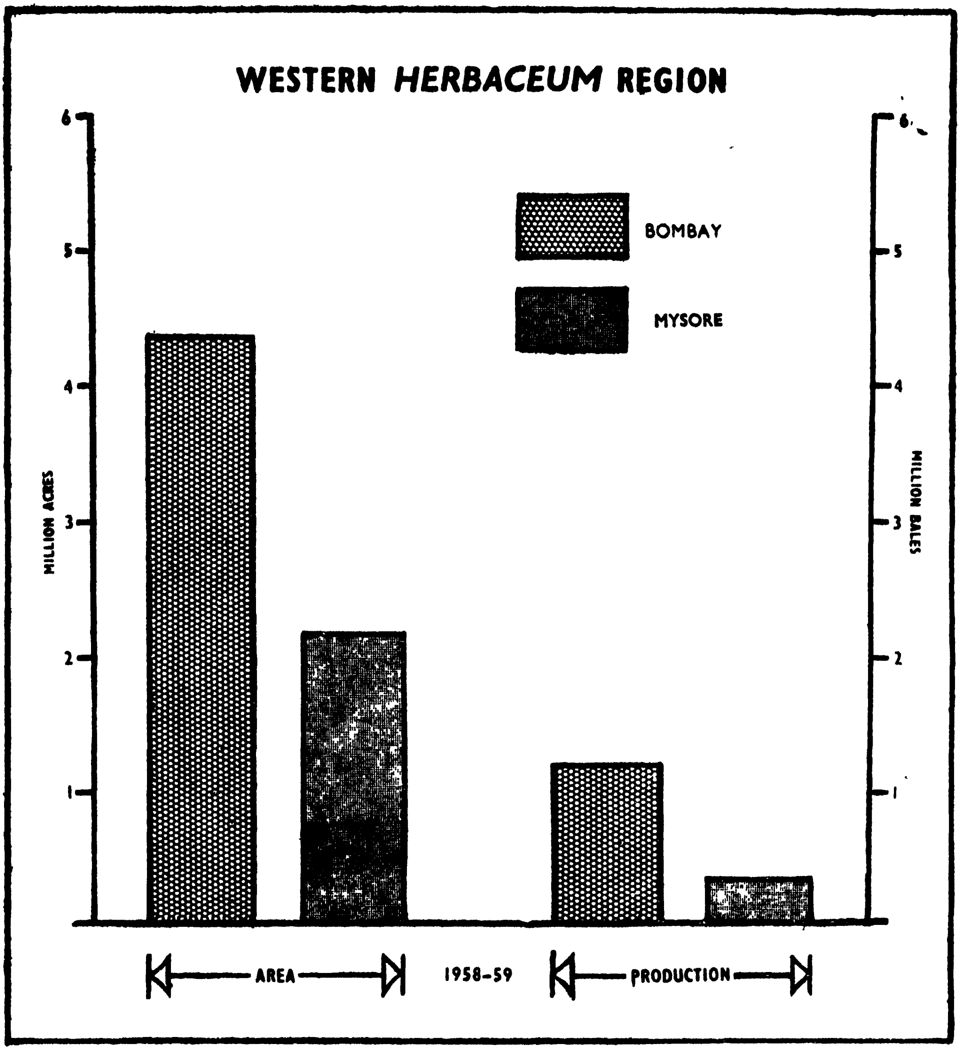


Fig. 30. State-wise Area and Production of Cotton in the Western *herbaceum* Region—1958-59

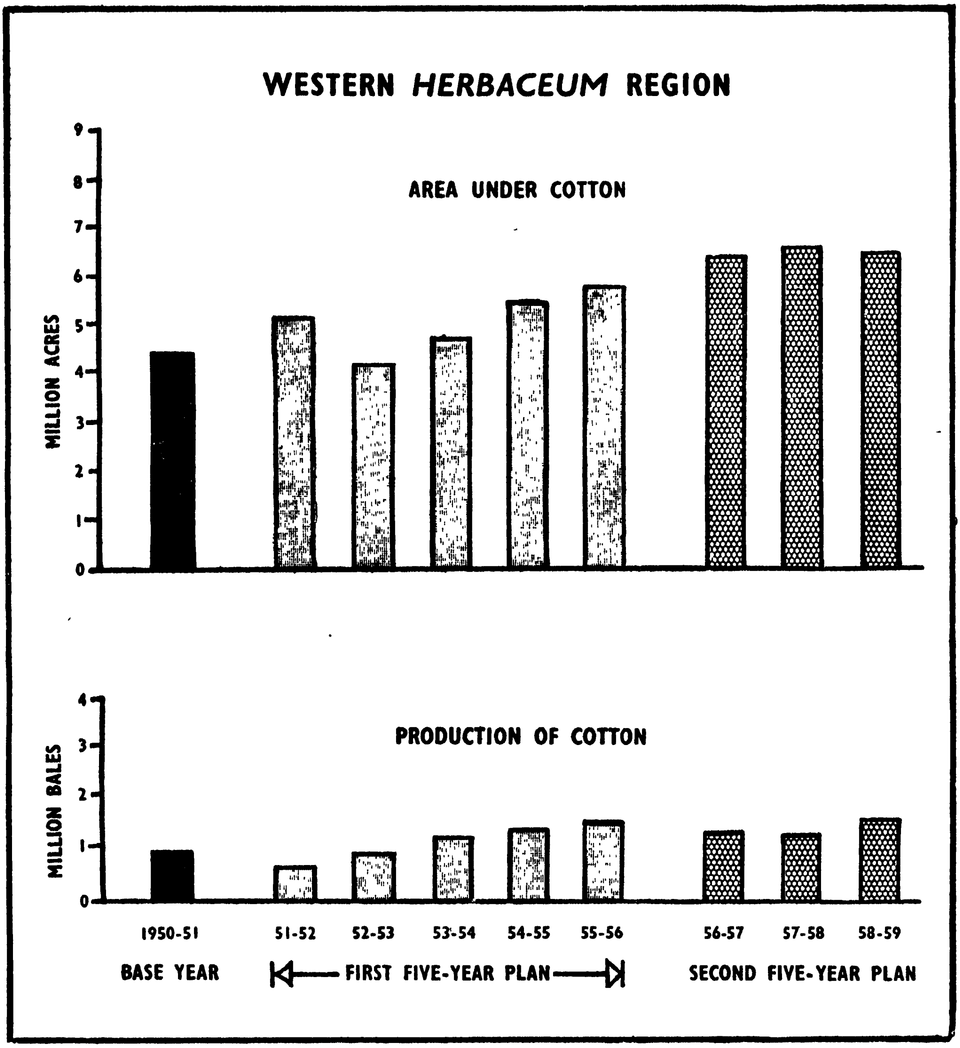


Fig. 31. Area and Production of Cotton Dnring the First and Second Five-Year Plan Periods in the Western *herbaceum* Region

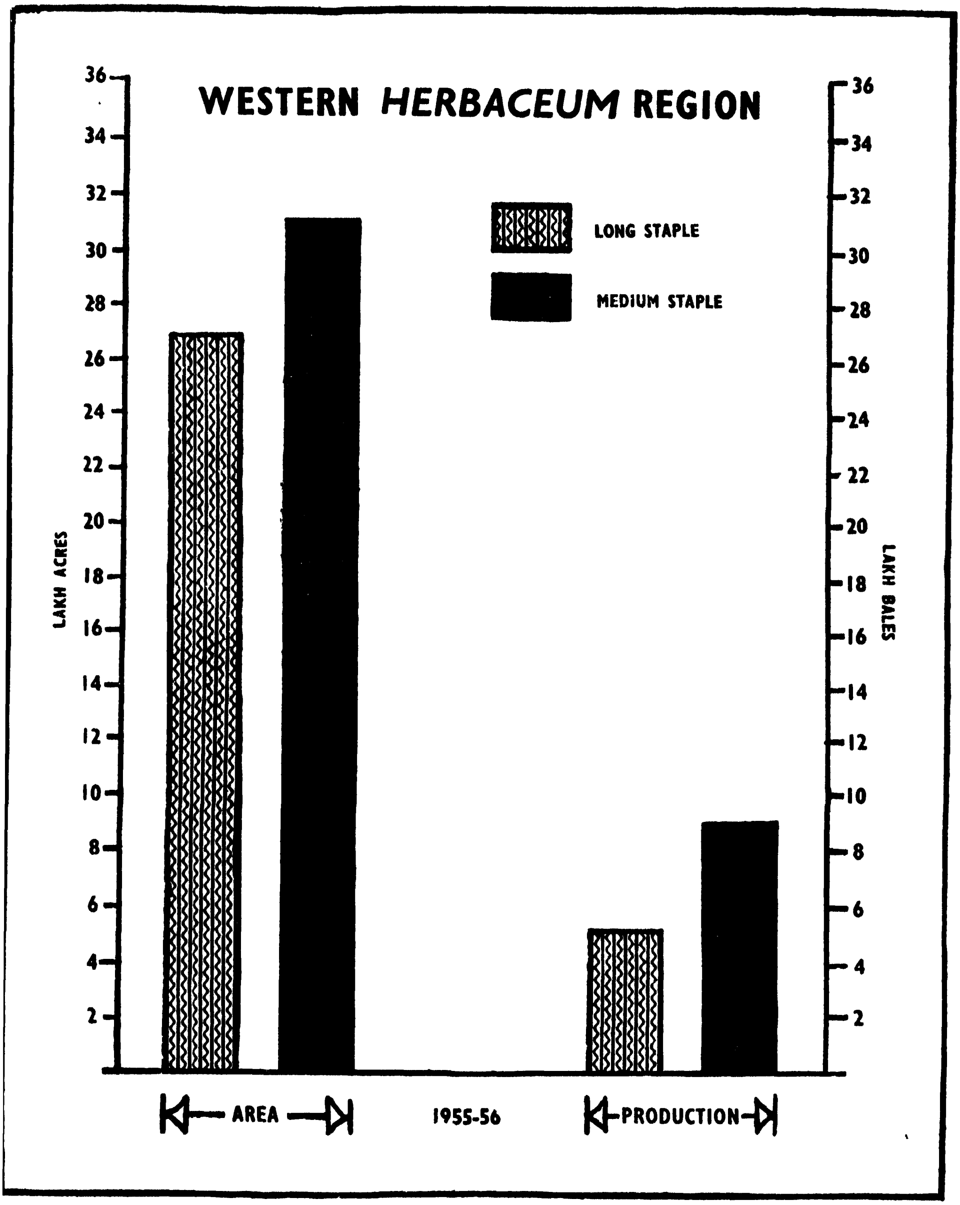


Fig. 32. Area and Production of Cotton According to Different Staple Lengths in the Western *herbaceum* Region

Each of the sub-regions or tracts will now be dealt with separately (Patel, 1941).

SOUTH GUJERAT COTTON TRACT

The tract consists of the area lying south of the river Narmada, i.e., Ankleshwar *taluka* and Rajpipla sub-division of Broach district, the whole of

Surat district, and Nawapur and Akkalkuwa *talukas* of West Khandesh district. The area under cotton in the tract is nearly 6,50,000 acres (forming about 30 per cent. of the total cultivated area) producing about 2,50,000 bales of cotton. The tract is specially important for cotton production as it grows the best quality of Surti (*herbaceum*) cotton for which the conditions are particularly favourable.

SOILS AND CLIMATE

Gujerat consists essentially of a flat plain lying almost at sea level. The general aspect of South Gujerat region and especially of the portion from within five miles of the sea to 20 miles inland, where cotton is chiefly grown, is that of a flat plain formed by the alluvium deposited in the basins of the Tapti and the Narmada rivers. The soil being derived from 'trap' (basalt) has all the characteristics of what is popularly known as the black cotton soil, varying in depth (four to six feet) and stickiness from place to place. At the lower depths, the soil is yellowish. All over it has a light sprinkling of lime nodules or *kankar*. These soils expand on wetting, and contract and crack deeply and widely on drying. The cracking of the soil is considered by the people to be a great advantage as it leads to the mixing of the soil with the sub-soil, either during the process of cultivation or during the first rains. Hence such soils are called self-ploughing soils. With the first rains, the flow of water into the cracks, carrying with it a large amount of surface soil, leads to the absorption by the soil of a very large amount of rain, even up to seven or eight inches in one continuous fall, without surface wash or erosion, and to the conversion of the field into a series of small basins. Once the soil is fully saturated any additional heavy and continuous rain causes water to stagnate on the surface.

The water drains so slowly that a water-logged condition is temporarily created. This type of soil is highly retentive of moisture. From the chemical point of view, the soil contains much lime. The available potash and phosphoric acid is about normal for this class of soils in the tropics. While most of the tract has such black soil, the soils of a part of Olpad *taluka* and Hansot Mahal are somewhat saltish. The soils of part of Nawapur, Akkalkuwa, Songadh, Mandvi and Mangrol *talukas* and Rajpipla sub-division are not so deep and have a substrata of *murram* (partially decomposed rock admitting of easy drainage) and are undulating. Soils on the banks of Tapti and Narmada rivers are deep and loamy and are very fertile.

Rainfall. As the soil is typical black cotton soil, the rainfall too is quite adequate. The average annual rainfall in the tract varies from 60 inches in the south to 40 inches in the north, though the figure varies from season to season. It is entirely concentrated in the months of June to October. July is usually the month of the heaviest rainfall, recording on an average about 30 per cent. of the season's total. The distribution of rainfall is not so even. Heavy and continuous rains in July, resulting in water-logging, retard the growth of the crop or even cause rotting, necessitating re-sowing or sometimes delay in normal sowing. Moderate showers alternating with sunshine in August and soaking rains in the latter part of September ensure a good cotton crop. Table 131 shows the monthly, yearly and average rainfall of the past ten years, as recorded at the Agricultural Research Station, Surat, a typical representative place for South Gujerat cotton tract.

Figure 33 shows the distribution of rainfull in the Western *herbaceum* Region.

Temperature and Humidity. The temperature reaches its lowest level during the months of December-January. The average monthly minimum temperature for the past five years ranged from 53° to 59° F. in these months, the absolute minimum being 44° F. The temperature reaches its maximum in April, the average for the past five years being 99° F. and the absolute maximum being 113° F. Cotton is normally sown in June and the crop is harvested from February to April. The period of most rapid development of the plants is in September-October, i.e., after the rains are practically over. October, however, is a very hot month. After October, the rate of growth diminishes. Flowering begins in November and boll development in December-January. The rising temperature in March with the fall of dew causes boll opening. Cold northerly winds from December to February adversely affect the flowering and bolling in the cotton crop. There is practically no danger of the occurrence of frost in the tract, as shown by the absolute minimum temperature during the past five years. The humidity during the boll development and ripening period, i.e., in the months of January-February, ranges from 55 to 67 per cent. as recorded at the Agricultural Research Station, Surat. The details of temperature and humidity are given in Table 132. In the south of Surat, in Navsari locality, humidity is comparatively high; this results in better quality of cotton although the variety may be the same.

IMPROVED VARIETIES

Early Attempts at Cotton Improvement by Introduction of Exotic Cottons. The first attempts at cotton improvement related to the introduction of exotic varieties of the New World group of cottons. By the close of the 18th century, American cotton began to be regularly received in England. The constantly increasing demand for cotton excited the interest of the East India Company, which tried to have a larger share of the lucrative trade. Shortly after Hove's visit, it commenced a series of experiments with a view to improving the quality of cotton produced in India. Further, in anticipation of deficient supply from the U.S.A., a secondary source of supply from India had to be looked for. The direct introduction of American cotton was the first attempt to produce good quality cotton in India. The experiments started with Bourbon cotton as early as in 1797, but met with no success. From 1829 to 1841, the East India Company made strenuous efforts to have

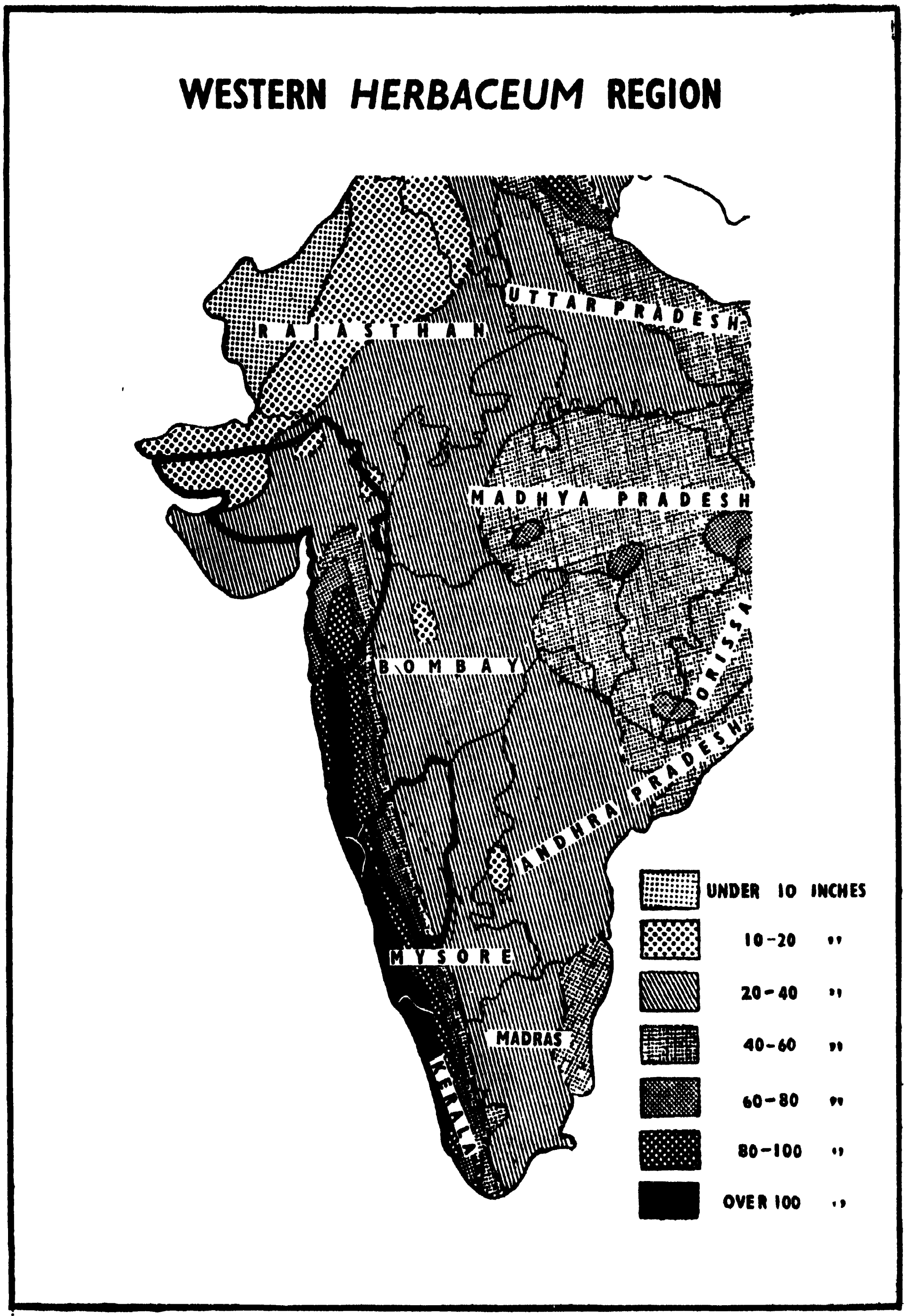


Fig. 33. Rainfall Pattern of the Western *herbaceum* Region

TABLE 131. MONTHLY, YEARLY AND AVERAGE RAINFALL FROM 1946 TO 1955 AT THE AGRICULTURAL RESEARCH STATION, SURAT

Month	Year										Average
	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	
January	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·06	0·00	0·00	0·01
February	0·00	0·00	0·00	0·10	0·00	0·00	0·00	0·00	0·03	0·00	0·01
March	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·39	0·00	0·04
April	0·00	5·70	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·57
May	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00
June	15·82	0·00	0·94	0·87	0·85	4·98	8·85	9·07	3·31	3·71	4·84
July	14·06	8·07	2·96	12·79	22·06	10·23	7·77	14·95	24·17	2·09	11·92
August	18·51	7·96	6·69	9·21	1·51	7·83	2·36	30·73	7·71	7·30	9·98
September	11·64	13·59	1·33	19·19	4·79	0·00	1·00	3·19	38·29	10·71	10·37
October	0·00	0·33	2·97	3·26	0·19	0·04	0·20	0·00	0·82	3·17	1·10
November	7·32	0·00	1·81	0·00	0·00	0·14	0·00	0·00	0·00	0·00	0·93
December	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·82	0·00	0·08
Total	67·35	35·65	16·70	45·42	29·40	23·22	20·18	58·00	75·54	26·98	39·85

TABLE 132. MONTHLY AVERAGE, MAXIMUM AND MINIMUM TEMPERATURES AND HUMIDITY FROM 1951 TO 1955 AS RECORDED AT THE AGRICULTURAL RESEARCH STATION, SURAT

Month	Year															Average		
	1951			1952			1953			1954			1955					
	Max.	Min.	Humi.	Max.	Min.	Humi.	Max.	Min.	Humi.	Max.	Min.	Humi.	Max.	Min.	Humi.	Max.	Min	Humi.
January	86·8	53·4	59	90·5	55·1	55	86·5	56·9	65	85·0	53·9	64	87·2	57·2	67	87·2	55·3	62
February	91·1	56·3	56	91·2	58·4	66	95·8	60·9	58	87·8	61·6	63	91·7	59·0	65	91·3	59·2	62
March	100·1	66·4	59	96·4	64·2	61	101·4	68·2	63	97·1	67·7	59	96·3	66·9	77	98·3	66·7	64
April	94·9	72·7	67	99·6	71·7	72	100·7	74·5	69	102·6	72·5	64	99·0	70·0	61	99·4	72·3	67
May	100·0	77·7	72	97·8	82·3	75	95·8	80·2	72	96·9	80·4	79	97·3	79·2	74	97·8	80·0	74
June	95·1	81·8	76	92·8	82·2	78	94·0	80·9	78	95·4	79·5	82	92·4	80·1	79	93·9	80·9	79
July	90·3	78·4	87	88·2	79·5	84	88·5	78·4	89	86·7	77·8	91	91·6	69·5	83	89·1	76·7	87
August	87·8	74·3	88	87·5	78·3	84	85·2	77·0	89	88·1	77·4	87	87·6	77·4	87	87·2	76·9	87
September	95·8	75·7	74	90·1	75·6	82	89·3	76·2	87	85·3	76·0	87	87·7	76·2	93	89·6	75·9	85
October	97·3	68·8	51	95·9	71·2	79	97·6	70·5	64	90·2	68·3	71	92·4	71·0	81	94·7	70·0	69
November	95·5	64·1	61	93·6	57·6	64	93·6	60·2	57	93·1	59·8	62	90·6	56·9	72	93·3	59·7	63
December	90·9	54·6	62	91·4	58·8	60	91·1	55·2	60	84·6	56·4	67	87·1	54·9	69	89·0	56·0	64

the exotic long staple cottons grown in India. Large sums were spent in the form of awards and 12 planters were invited from the southern U.S.A. (1840), with a view to establishing the cultivation of New Orleans cotton. Three of these started work at Broach. In 1841-42, about 350 *bighas* of land was sown with New Orleans seed, which "vegetated in a most luxurient manner, growing strong and healthy, showing abundance of blossoms, but no sooner had the first rains ceased than it became blighted and stunted from which it never afterwards recovered." The planters expressed the opinion that the American cotton plant could not be cultivated so as to yield a profitable return or equal the quality and quantity of the same plant in America (Mackenna, 1918). Extensive trials were also made in Surat, Ahmedabad and Kaira and there too, it was the same melancholy record of experiments undertaken and abandoned. The attempts were continued till 1873 when they were finally given up (Gammie, 1905). Even the trials of foreign tree cottons at Surat, Dohad and Nadiad did not give any promising results as compared to the indigenous annual cottons. Thus, in spite of repeated efforts for a period of about 100 years, no exotic cotton could be successfully introduced in Gujerat. Hence, attention was turned to the possibilities of improving the indigenous cottons already in cultivation and found responsive to the conditions of the tract.

Improvement of Indigenous Varieties of Cotton by Scientific Methods of Plant Breeding. With the establishment of the research stations at Surat (1896), Broach (1913), Viramgam (1921) and Dharwar (1904) cotton was the principal crop taken up for improvement by selection and hybridisation. To start with, selection of plants with desirable characters was taken up at Surat, but later, since 1917, the system of pedigree culture has been adopted. Detailed studies showed that what ordinarily passed under the name of a cultivated cotton variety, e.g., Surti-Broach, Goghari, or Wagad or Kumpta consisted of several sub-types differing in botanical, agricultural and economic characters (Kottur, 1920; Patel, 1921, 1924; Patel and Mankad, 1926). By the application of scientific methods of crop breeding, involving the study of thousands of individual plants for judging the behaviour of selected types for uniformity of various traits, from year to year, and by their systematic trials with the ordinary varieties grown by farmers to evaluate their merits, true breeding improved types have been secured which can be relied upon for their constancy of behaviour and supply of uniform commercial product to the cotton industry. The important characters for improvement are : (*i*) increase in yield; (*ii*) ginning outturn; (*iii*) lint length; (*iv*) fibre qualities, associated with higher spinning; and (*v*) disease resistance. Further improvement of the selected types was taken up by hybridisation with a view to augmenting or incorporating in them the desirable characters from other types specially possessing them and thus synthesising new types of cotton of superior merit. Substantial progress has been made in this direction also.

Cotton Improvement in South Gujerat Tract. Research work on cotton improvement for the tract is being done at the Agricultural Research Station, Surat. As already stated, the efforts to acclimatise exotic cottons were unsuccessful (except in certain tracts of the Bombay-Karnatak), the failure being attributed to their great susceptibility to attack of jassids and red leaf blight and unfavourable climatic conditions, resulting in lower yield. It was conclusively shown (Annual Report of Government Farm, 1896-97) that improvement of Indian cotton was not likely to be brought about by the introduction into the district of exotic varieties or even varieties indigenous to other parts of India. Cotton responds stubbornly to any change of this sort, and it is more than probable that varieties generally found cultivated in any particular district are the varieties which suit the district best and pay the cultivators best. The variety of cotton that was being grown at that time was known as Surti-Broach or Surti Local, belonging, as already stated, to the species *G. herbaceum* race *wightianum*. As a result of mass selection work in this variety (best bolls from most robust and vigorous plants) from 1904 to 1916 and unit selection since 1917, several strains have been isolated. They differ from one another in characters having direct or indirect economic importance and which breed true. Of these, strain 1A Long Boll proved to be of special economic value. As compared to Surti Local, it gave a higher yield of seed cotton by about 10 per cent., had a higher ginning by 6 per cent., resulting in about 25 to 30 per cent. higher yield of lint. In fibre qualities, it was very nearly equal to local cotton. Hence, this strain was recommended for general cultivation in South Gujerat in 1919-20. But from 1922-23, the distribution of this type was discontinued in favour of strain 1027 A L. F., the quality cotton of South Gujerat. This strain is derived from a hybrid 1027 originally made by Prof. Gammie at Kirkee Farm in 1901 between Goghari and Kumpta cottons. Two specially good plants (1027 A) were selected in 1904. Continued selection gave, in 1907, two new types 1027 A, Long and Coarse and 1027 A, Long and Fine, the latter being styled 1027 A L. F. in 1910-11. The selection work was continued thereafter and the present 1027 A L. F. is a pure line from an individual selection made in 1917-18 (Annual Reports, Surat Agricultural Station, 1907-15 and Patel, 1924). Though 1027 A L. F. has a lower ginning value by four per cent. than 1 A L. B. it is superior to the latter in staple length, and possesses silky feel and hence fetches higher price. The results of comparative performance of Surti local and 1027 A L. F. as tried at the Agricultural Research Station, Surat, are given in Table 133. Strain 1027 A L. F. was grown in 1922-23 on all the cotton area of the Surat Farm and the resulting seed was distributed in a group of villages near the Farm (Athwa Group) for growing in the 1923-24 season. From this year, it further spread in the South Gujerat cotton area. It occupied a major portion of the tract and represented the highest water mark in staple qualities amongst all Indian cottons. It was responsible for saving the reputation of the Surat tract cotton, which was threatened by the intrusion of the high ginning, but short-stapled, inferior variety Goghari. Intrinsically, it was considered to be equal in value to the Middling American, which controls the market of the world. For about 20 years, 1027 A L. F. held the field and occupied a position of pride in the tract and in the country. Efforts were made to further explore the local cotton but an all round combination surpassing 1 A L. B. or 1027 A L. F. could not be had. Some types, with distinctly long staple of about 1-1/32 inch (but lower in ginning percentage) or early maturing potentials were obtained. They were only useful as parents in hybridisation. Crosses were also made between 1027 A L. F. and the high ginning Goghari type, but no type which could be recommended for general cultivation in place of 1027 A L. F., emerged.

TABLE 133. COMPARATIVE PERFORMANCE OF SURTI LOCAL AND 1027 A L. F. AT THE AGRICULTURAL RESEARCH STATION, SURAT

Year of release	Variety	Yield of *kapas* (lb. per acre)	Ginning percentage	Mean fibre length (inch)	Fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.)
1923-24	Surti Local	505	34·8	0·85	0·232	20 to 24
	1027 A L. F.	537	35·6	0·95	0·166	30 to 35

The earlier distribution of the high ginning, medium quality, type 1 A L. B. created a situation in which, as far as monetary returns per acre were concerned, it always remained a rival of 1027 A L. F. which inspite of its superior quality could not cover more than 50 per cent. of the cotton area of Surat tract. There was a tendency on the part of the farmers to grow 1 A L. B. either by itself or as a mixture, because 1027 A L. F. could not secure adequate premium over 1 A L. B. to compensate for its lower yield of seed cotton and lower ginning percentage. Further, 1027 A L. F. was found to be rather a delicate cotton, not very adaptable throughout the tract. It was, therefore, vital to increase the ginning percentage of 1027 A L. F. and at the same time retain its quality. A cross was, therefore, made between 1027 A L. F. and 1 A L. B. in the year 1930 and a synthetic type called Segregate 8-1 (subsequently named as Suyog) was evolved. Comparative trials of Suyog with 1027 A L. F. showed that it gave nine per cent. more yield of seed cotton and had three per cent. higher ginning value, resulting in about 18 per cent. more yield of lint.

This segragete is very nearly equal to 1027 A L. F. in fibre length but it is not as silky. On an average, it gives about rupees 10 more per acre to the farmer than 1027 A L. F. It permanently set at rest the 25-year old controversy about the preference of 1 A L. B. or 1027 A L. F. as a profitable variety to be grown in the South Gujerat tract, ousting the medium quality cotton 1 A L. B. from the field. It is a happy combination of desirable characters from both the parents, as it approaches 1027 A L. F. in staple length and 1 A L. B. in ginning percentage, hence, it is named Suyog (Patel, 1947). From 1945, Suyog became approved variety of cotton, to be grown in the whole of South Gujerat cotton tract. The results of comparative performance of 1027 A L. F., 1 A L. B. and Suyog are given in Table 134.

Hybridisation experiments were continued and crosses of 1027 A L. F. with Kumpta-Jayawant gave types which were earlier than 1027 A L. F. by two weeks and were superior in spinning qualities (41's *vs* 35's) but were inferior in yield and ginning percentage. Hence, they were of no immediate use. The next stage of improvement aimed at evolving a type of cotton which, while giving a satisfactory yield, should be as high ginning as Suyog but superior to it in fibre qualities. At the same time it should be resistant to wilt disease, then of a common occurrence in certain parts of the tract, to which both 1027 A L. F. and Suyog (and even 1 A L. B.) were susceptible. Further, Suyog was found to be somewhat later in ripening than 1027 A L. F. and hence its yield was adversely affected in years of drought. The new strain was, therefore, required to be earlier than Suyog. Several crosses, involving wilt-resistant types as one of the parents, were tried. Of these, a segregate 2087, from the cross of Vijay B. C. 1-2 × 1027 A L. F. back-crossed to Vijay B. C. 1-2 (originally obtained from Broach in 1943-44 and subsequently tried at Surat through intensive selection and trial, including that for wilt resistance under heavily wilt infected conditions) has been obtained. It combines to a pretty high degree the desired economic and agronomic characters. This new strain is distinctly earlier than Suyog and almost completely wilt-resistant. On an average, it gives about 40 lb. more of seed cotton per acre, and has very nearly as high a ginning percentage as has Suyog. It has slightly longer and finer fibre than Suyog, resulting in better spinning performance. Table 135 shows the comparative performance of 1027 A L. F., Suyog and Strain 2087. Growing of Strain 2087 is thus conducive to greater monetary returns, by about rupees 15 per acre, than Suyog (Patel and Bhat, 1953). Strain 2087, now named Vijalpa, is being distributed in the South Gujerat cotton tract from the 1952-53 season and has practically covered the entire area of the tract. Experiments are now in progress to evolve types possessing long staple of full one inch in combination with other desirable economic and agricultural characters through crosses with long staple *herbaceum* types which are by themselves selections from local cotton, or are derivative types from crosses between Iranian and Surat *herbaceum* types. The comparative performance of all the progressively evolved strains for the South Gujerat cotton tract is given in Table 136.

COTTON CULTIVATION

Preparatory tillage begins by about the end of April and consists of two

TABLE 134. RESULTS OF COMPARATIVE TRIAL OF 1027 A L. F., 1 A LONG BOLL AND SUYOG AT THE AGRICULTURAL RESEARCH STATION, SURAT

Variety	1934-35	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	Average
				Yield of *kapas* (lb. per acre)					
1027 A L. F.	751	553	391	476	422	518	654	357	515
1 A Long Boll	867	615	481	585	431	606	704	408	587
Suyog	821	571	449	549	405	579	645	400	552
				Yield of lint (lb. per acre)					
1027 A L. F.	259	207	143	156	150	183	232	120	181
1 A Long Boll	345	246	193	216	172	243	273	157	231
Suyog	317	224	176	196	157	223	245	147	211
				Ginning percentage					
1027 A L. F.	34·6	37·5	36·6	32·8	35·5	35·4	35·4	33·5	35·2
1 A Long Boll	39·8	40·1	40·2	37·0	39·9	40·1	38·7	38·5	39·3
Suyog	38·7	39·3	39·1	35·8	38·8	38·6	38·0	36·8	38·1
				Mean fibre length (inches)					
1027 A L. F.	0·96	0·93	0·99	0·91	0·93	0·94	0·91	0·87	0·93
1 A Long Boll	0·90	0·85	0·87	0·84	0·84	0·86	0·82	—	0·85
Suyog	0·96	0·92	0·93	0·92	0·91	0·92	0·91	0·85	0·92
				Fibre weight per inch (10^{-6} oz.)					
1027 A L. F.	0·183	0·197	0·204	0·185	0·204	0·175	0·199	0·169	0·190
1 A Long Boll	0·178	0·218	0·211	0·180	0·210	0·185	0·212	—	0·199
Suyog	0·183	0·212	0·209	0·191	0·211	0·188	0·221	0·194	0·201
				Spining capacity (H.S.W.C.)					
1027 A L. F.	34	34	31	30	26	32	31	31	31
1 A Long Boll	34	27	28	27	24	32	27	—	29
Suyog	36	28	28	32	26	31	29	28	30

TABLE 135. AVERAGE PERFORMANCE OF STRAINS, 1027 A L. F., SUYOG AND 2087 (VIJALPA)

Type	Yield per acre (lb.)		Ginning percentage	Mean fibre length (inches) (average of 2 years–1949-50 and 1950-51)	Mean fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.) (average of 2 years–1949-50 to 1950-51)
	Kapas (average of 3 years–1949-50 to 1951-52)	Lint				
			Surat Farm			
1027 A L. F.	347	118	34·0	1·00	0·183	36's
Suyog	349	131	36·7	0·96	0·194	34's
2087	387	147	37·3	0·98	0·170	35's
			District trials in Suyog tract			
Suyog	524	193	36·6	0·97	0·185	34's
2087	568	205	35·9	0·98	0·154	38's
			District trials in Nawapur *taluka* of West Khandesh district			
1027 A L. F.	355	113	31·6	0·90	0·160	34's
2087	389	134	34·3	0·93	0·145	37's

TABLE 136. COMPARATIVE PERFORMANCE OF SURTI LOCAL, 1 A LONG BOLL, 1027 A L. F., SUYOG AND 2087 (VIJALPA) AT THE AGRICULTURAL RESEARCH STATION, SURAT

Variety	Yield of seed cotton (lb. per acre)			Ginning percentage			Mean fibre length (inches)			Fibre weight per inch (10^{-6} oz.)			Spinning value (H.S.W.C.)		
	1954-55	1955-56	Average	1954-55	1955-56	Average	1954-55	1955-56	Average	1954-55	1955-56	Average	1954-55	1955-56	Average
Surti	647	717	682	32·8	34·9	33·8	0·93	0·90	0·92	0·220	0·222	0·221	24	27	25
1A Long Boll	684	799	741	40·0	41·5	40·7	0·91	0·89	0·90	0·195	0·181	0·188	33	30	31
1027 A L. F.	540	725	632	35·2	37·8	36·5	0·98	0·95	0·97	0·160	0·180	0·170	33	33	33
Suyog	619	773	696	38·5	40·1	39·3	0·95	0·95	0·95	0·184	0·202	0·193	29	32	31
2087 (Vijalpa)	713	882	797	38·5	42·0	40·2	0·99	0·94	0·97	0·149	0·165	0·157	34	32	33

to three harrowings with a blade-harrow and removing the stalks and stubbles of the previous crop. The local practice is to give about 10 to 15 cart-loads of farm yard manure at an interval of five years. During recent years, however, intensive cultivation of cotton is being gradually adopted and groundnut or castor cake at the rate of 100 to 150 lb. per acre or sulphate of ammonia (20 lb. N) is being applied eihter at the sowing time or after the establishment of the crop. Simultaneous green-manuring with *san*, *China mug* or *udid* grown in between cotton rows, is also being done to a limited extent. .

Sowing. Sowing is done either by dibbling or drilling, the former method being particularly useful when the soils remain too wet for carrying out the operation by bullock power. Sowing in dry mulch, before the monsoon, is resorted to in some parts of the tract to attempt the crop's early establishment which sometimes gets delayed if the first rains are continuous because the soil is rendered unsuitable for timely sowing. Generally, however, sowing is done after the first heavy rains by the drilling method through bullock power.

In parts of Olpad, Mandvi, Rajpipla, Valod, Songadh and Nawapur *talukas*, drilling is prevalent, while in the remaining parts of the tract, both the systems are in vogue. The crop is normally sown by the end of June, but the sowing operations last till the end of July or the middle of August in low lying fields. The seed rate varies from 6 to 10 lb. per acre. The spacing varies from 5′×2′ to 7′×3′. Such wide spacing for cotton is rather exceptional ; it was, however, gradually evolved from the close spacing of 3′×1′ followed some three decades ago. The spacing experiments and the experience of the farmers show that there is no reduction in yield by wide spacing which particularly facilitates weeding and inter-cultivaton operations. The narrow spacing of 3′×1′ is generally followed in the hilly tracts of Nawapur and Mandvi *talukas* and parts of the Rajpipla sub-division. The very wide spacing of 7′×3′ is followed in Bhatha lands and in areas where cotton crop is irrigated. The crop is thinned out to the required distance by the end of August. One or two plants are kept at each dibble in the case of the dibbled crop. Further tillage consists of four to five interculturings, with a blade-harrow and two to three hand-weedings. The inter-tillage operations cease by October. The period of rapid, vegetative growth of the plants is during September and October.

Rotations. The usual rotation followed is a two-year rotation of cotton followed by *jowar* (*sorghum*) mixed with *tur* (*Cajanus indicus*) and other pulses. Cotton is also rotated with groundnut following *jowar* where the soil is suitable for groundnut cultivation. In some parts, cotton after cotton is taken continuously for two or three years and subsequently rotated by *jowar*, groundnut or *til-tur* mixture for one year.

Irrigation. The crop is mainly grown as a rainfed crop in the tract.

The sub-soil water being mostly brackish is unfit for irrigation. However, where facilities for irrigation with suitable water from wells are available, one or two waterings are given until November, particularly in years of drought. With the recent development of canal irrigation, the whole aspect of cotton cultivation will considerably change both for greater production through intensive cultivation and for growing long staple American cotton, which at present is required to be imported into the country.

PESTS AND DISEASES

Pests. Major cotton pests of the region are : Spotted Bollworm ; Pink Bollworm, and Wooly Mite.

Minor pests are: Cotton Stem Borer, Red Cotton Bug, and Dusky Cotton Bug.

In addition to the bollworms, the pests of major importance causing serious damage to the Indo-American variety being recently cultivated in the tract are: Thrips, Jassids, Aphis and Leaf Roller.

Spotted Bollworm (*Earias fabia and Earias insulana*) : The caterpillars are brownish white and have a dark head. They have a number of black and brown spots on the body ; hence the name spotted bollworm. A full-fed larva measures about three-fourths of an inch. The cotton crop commences to grow vigorously soon after the close of the monsoon and at this time, spotted bollworms appear in cotton fields. In the beginning, vegetative shoots are destroyed in large numbers, during September and October, resulting in the development of side branches and making the plant bushy in appearance. The larvae turn their attention to flower buds as soon as they begin to develop and the damaged buds drop down from the plants. Similarly, young bolls also drop following their attack. Older punctured bolls remain attached to the plants, resulting in damage to the yield and quality of cotton. The larval population is very high during November and December. It declines at the end of December or the beginning of January, partly due to the cold weather and partly due to the activities of the parasites. The pest is of common occurrence and is taken for granted as a normal seasonal feature in cotton cultivation. The study and control of the pest formed the subject of continued research at Surat for about 10 years through a scheme financed by the Indian Central Cotton Committee. The plants protected from bollworm were found to be early by about a month and also gave a 40 per cent. higher yield (Kasargode, 1927; Joshi *et al.*, 1941). The control measures recommended are: (*i*) uprooting the cotton and other malvaceous plants growing round about during the off-season in order to prevent the carry-over of the pest. This is best done by pulling out the stalks immediately after harvest, with a plant puller specially designed for the purpose and leaving no chance for the sprouting of fresh shoots which supply food to the pest during the off season ; and (*ii*) collecting and burning the affected parts.

Pink Bollworm (*Platyedra gossypiella*) : As compared to the spotted bollworm, the damage from this pest is limited. The caterpillar is whitish in the beginning but turns pinkish as it grows up. A full grown caterpillar measures about three-fourths of an inch. Unlike the spotted bollworms, these caterpillars never attack the shoots. They feed inside the bolls and make them drop down. The damage is chiefly done by destroying the seed, spoiling and staining the lint and causing defective opening of the boll. The larva pupates in the boll or in the seed or in the soil The remedial measures, which are of a preventive nature, consist of fumigating the seed with carbon bisulphide or heating it to a temperature of about 145° F. As a further measure, the stalks should be removed immediately after the harvest and burnt in order to destroy both the pest hibernating in the unripe bolls and the early infected and shed bolls.

Wooly Mite or Chhaseo : In certain years this pest becomes very serious and greatly affects the yield. The leaves and young shoots present an ashy or wooly appearance due to the over growth of leaf tissues caused by the feeding mites. The pest is an eriophyed mite, microscopic in appearance and whitish in colour. The feeding of the mites results in a wooly growth on the leaves and growing shoots, making them crumpled. In cases of heavy infestation, the entire plant presents a wooly appearance, thus checking further development and adversely affecting the flowering and fruiting, and consequently the yield. Ordinarily, the mite pest can be controlled by sulphur but as indigenous cottons are adversely affected by the use of sulphur, the control measures are difficult.

Stem Borer (*Sphenoptera gossypii*) : This is a beetle of dark brown colour which lays eggs on the bark of the cotton stem. The larva, emerging from the egg, which is white and over an inch in length when full grown, bores its way into the stem and feeds inside. The stem gets swollen at the base and the plant dries up. This is, however, not a serious pest, occurring only in certain years of drought. The best course to control the pest is to promptly remove and destroy the dry, affected plants.

Red Cotton Bug : The adult is about half an inch long. Its colour is bright red. Its eyes, scutellum and antenna are black. The adults and nymphs suck the plant sap and impair its vitality. In addition, they feed on the seeds and lower their oil content. Due to their excreta, the lint gets soiled. For control measures, the adults and nymphs can be collected in large numbers by shaking them in a tray containing a little kerosene oil added to ordinary water.

Dusky Cotton Bug : The adults are small in size and dusky coloured and about a quarter of an inch long. The adults and nymphs are found feeding in open bolls and also on those bolls that are damaged by bollworms.

The lint gets stained as the bugs get crushed during the ginning operation. For control measures the adults and nymphs can be collected by shaking them in kerosenised water. This too is a minor pest.

Thrips: The insects are very tiny and delicate and light yellow in colour. They are found in large numbers rapidly moving, mostly on the lower side of the leaves but they also feed on the upper surface. They scrape the epidermis and suck the cell sap of the leaves which become brownish and copper-coloured and subsequently dry up. The insect is particularly active during the latter part of the monsoon. The pest becomes serious in September-October, especially in years of failure of late rains. It can be controlled by the use of insecticides like DDT or BHC.

Jassids: The nymphs and adults are very small in size and pale green in colour and they are found in large numbers on the lower surface of leaves. They pierce the plant tissues and suck the cell sap. Initial damage is noticed when the borders of the leaves get yellowish. Subsequently, the leaves crumple up, resulting in the stunted growth of the plants. The leaves turn reddish ultimately and appear to be affected by red leaf blight disease. These insects are not able to cause damage to *desi* or local *herbaceum* cottons but the American types of cotton (particularly smooth or sparsely hairy leaf types) are usually attacked by them. The pest can be controlled by dusting or spraying with DDT.

Aphis: It is a small green or dark yellowish insect which multiplies rapidly. It abounds on the lower surface of the leaves and gives out a sugary juice, which makes them sticky. Ordinarily, the pest is controlled by its natural enemies—the predators and parasites. When the infestation is limited to a small extent, spraying of contact insecticides, like tobacco decoction, fish oil rosin soap, kerosene emulsion, etc., are effective in controlling the pest.

Leaf Roller (*Sylepta derogata*) : The caterpillars, which are green with a bluish mouth, roll up the leaves and feed on the green matter while remaining hidden in the leaves. The damp and cloudy weather favours the growth of the pest which is particularly seen in shady places. The control measures are : (*i*) the rolled up leaves, containing the caterpillars, must be removed and destroyed by burning; and (*ii*) if the infestation is heavy, the crop should be dusted with a mixture of sodium fluosilicate and ash in the proportion of 1:8 or with five per cent. DDT mixture.

Diseases. The common diseases of cotton are : Wilt, Root Rot ; and Angular Leaf Spot or Blackarm.

Wilt: This disease is restricted to certain black soil areas in the tract. It is a fungoid disease caused by *Fusarium vasinfectum* which remains in the soil as a saprophyte but becomes parasitic to cotton under certain favourable atmospheric temperature and soil moisture conditions. The fungus invades the roots and spreads to the stem, affecting the vascular tissues resulting in wilting of the plant, which ultimately dies. The roots and stem, when split open, show characteristic brownish streaks. The best way to control the disease is to select or breed types of cotton resistant to the disease. This is being done by growing the plant material under artificial conditions of heavy wilt infestation and by trying out resistant types selected under field conditions and *vice versa.* In fact, resistance to wilt disease is one of the requisite characters of the cotton strain which is recommended for general cultivation in the tract.

Root Rot (*Macrophomina phaseoli*) : This disease is generally found in the tract in scattered patches in sandy soils. As yet, there is no remedy for this disease. The dried up plants are generally found attacked by white ants.

Angular Leaf Spot or Blackarm (*Xanthomonas malvacearum*) : This is a bacterial disease first affecting the leaves with black lesions and later on the branches and stem and even the bolls. This disease particularly becomes serious under high rainfall and humid conditions with Indo-American cottons recently being grown in the tract. In the initial stages the infection can be controlled by treating the seed with a fungicide. It is, however, difficult to control secondary infection. The best way is to breed types, resistant to the disease. Some such types are already on hand from Indo-American plant material.

HARVESTING AND YIELD

Normally the crop reaches full flowering stage by December. About 25 to 30 per cent. of the squares or flower buds bloom into flowers and about 35 to 40 per cent. of flowers develop into ripe bolls (Joshi *et al.*, 1941). The bolls are mostly three-locked and the number of seeds per boll is about 21. The quantity of *kapas* per boll varies from 2.0 to 2.5 gms. or in other words, about 240 healthy bolls make one pound of *kapas.* The picking commences in February. The crop is harvested in three or four pickings at an interval of about a fortnight. The harvesting is over by April. Cotton in this tract is thus a long season crop, occupying the soil for about nine months. Generally the major harvest is over in the first two pickings. The produce is superior to that of subsequent pickings. The average yield of seed cotton is about 360 lb. per acre giving about 125 lb. of lint.

Agronomic experiments conducted on the Surat Farm under rainfed conditions show that the yield can be substantially increased by about 50 per cent. by the application of bulky manures with a top-dressing of artificial manure at the rate of 40 lb. N per acre. Usually, the application of superphosphate or sulphate of potash does not result in increased yield. However, the application of superphosphate in combination with higher doses of nitrogen shows better response than nitrogen alone. Such manuring leaves a margin of about Rs. 50 per acre after deducting the cost of the manure.

MARKETING AND GINNING

The produce is sold by the farmers in the form of seed cotton (*kapas*) through agents of private merchants, or the co-operative societies. The societies pool and gin *kapas* and sell the lint in the form of full-pressed bales. There are only a few regulated markets in the tract, at Nawapur in West Khandesh and at Hansot and Ankleshwar in Broach district. There is, however, a good net-work of co-operative cotton sale societies, which handle about 60 per cent. of the cotton produce of the tract. These societies gin the seed cotton and sell lint to the merchants and agents of different mills.

Originally, the cultivators in this tract had to sell their cotton to village *sahukars* (money-lenders) and *adatias* or middlemen. This practice made them increasingly dependent on the *sahukars* and added to their indebtedness. They could not realise the full price of their produce for want of fair and free competition in the primary markets where they mostly sold it. They also became victims of malpractices, such as manipulation of weights and measures and undue deduction for various items. The village *sahukars* used to supply seed for sowing purposes to the cultivators either on cash or credit. They gave advance to the cultivators either for their household requirements or for cultivation purposes. The cultivators in their turn had to sell their produce to the *sahukars* who had advanced the money. These *sahukars* sold the produce, collected from the cultivators, to various gin-owners. In some areas, the gin-owners also directly advanced money on condition that the cultivators should sell them seed cotton for the value of the money. The gin-owners and the *sahukars* charged interest at the rate of six to nine per cent. on the loan. Generally, the gin-owners used to send their *dalals* (middlemen) to villages for purchasing *kapas*. These *dalals* contacted the cultivators and settled the rate and the quantity of *kapas* to be sold. The cultivators sold their produce in two or three instalments according to the quantity of the produce and the suitability of the market rates. The *dalals* made the cultivators enter into contracts (*kabalas*) with the gin-owners for the purchases made by them. They were paid by the gin-owners Re. 1 to Rs. 2 per cart-load (12 Bengal maunds) of *kapas*. The cultivators delivered their produce at the ginning factory.

As a result of research work on cotton, improved varieties of cotton soon became available for general cultivation and systematic plans for distribution of pure seed of these varieties were put into operation by the Department of Agriculture, Bombay. Some unregistered groups of cultivators were organised. They sold their produce by a collective method, either as seed cotton or in the form of full-pressed bales. The average price realised was distributed amongst the cultivators after deducting the necessary expenditure. The resulting cotton seed was sold to the Agricultural Department. This was the beginning of the co-operative effort in cotton marketing.

The history of the co-operative movement for marketing of cotton in South Gujerat can be traced as far back as 1919, when the weak tendency of the cotton market and the refusal of merchants to purchase *kapas* from the producers, even at the lowest possible rates, made a few enlightened farmers of the tract to join and pool their *kapas* and sell it after getting it ginned. The pioneer co-operative cotton sale societies established between 1921 and 1925 had to face formidable opposition from the gin-owners who were also cotton merchants. The co-operative societies had to pay exorbitant ginning charges and were also denied other facilities usually allowed to the sellers. The societies and the farmers combined and formed the first co-operative ginning society at Rander, near Surat, in 1926. Such small societies had to depend for the pressing of lint on private cotton presses. Opposition from the trade continued till 1933 when it reached a climax.

The press-owners formed themselves into an association and fixed very exorbitant pressing charges. This situation created an immediate need for the co-operative society to have its own ginning and pressing factories. As the co-operative cotton sale societies were situated in the mofussil, away from Surat town, the chief cotton market of the tract, they experienced difficulty in disposing of the members' produce. In 1930, these co-operative cotton sale and ginning societies, therefore, formed themselves into the Southern Gujerat Co-operative Cotton Sale and Ginning Societies Union, Ltd., with the main object of facilitating their sales. The progress of the co-operative cotton sale movement in Surat district has been so steady and sound that by 1946-47, practically every *taluka* of the tract had a co-operative organisation for the purpose. The co-operative cotton sale societies have ginning and pressing factories throughout the tract except in West Khandesh district where there is not a single co-operative cotton sale society organised as yet. At present, there are 15 cotton ginning societies, with pressing arrangements at 13 factories. Thus, 60 per cent. of the produce is handled by the co-operative cotton sale societies. This movement is progressing well, particularly because the societies get a substantial premium for their agmarked and certified produce by the Agricultural Department, which also has its seed multiplication and distribution arrangements through them. At present, the cotton sale societies have a better reputation in the trade and a fairly good command in the market. Most of the societies handling cotton are single commodity co-operatives, dealing in cotton alone, while some deal in other crops as well. The pooling and deferred system of payment is universally adopted by all the cotton sale societies. The membership is confined to individual growers and the area of operation is limited to a group of villages. Practically every cotton sale society takes active part in the cotton seed distribution and multiplication scheme. When there is a difference of opinion between the workers and some members of the societies, new societies are formed from the same and adjoining villages. In the same village, cultivators may be members of two or three different societies. It is obligatory on all members to sell their *kapas* to the society. The defaulters are penalised by the imposition of fines. Each society advances money to the cultivators at the rate of Rs. 20 to Rs. 40 per acre of cotton grown to facilitate the cultivators in their agricultural operations. The cotton seed is distributed to the members on the directions of the Agricultural Department. The societies also prepare the area list of cotton sown by their members. When the cotton season commences in January-February, the members cart their *kapas* to the ginnery (co-operative or private) with which the cotton sale society has arranged for ginning the members' produce and where the society also opens its office. The produce obtained from different stages of seed multiplication, i.e., I, II and III Stages is stored and ginned separately under the supervision of the officer of the Agicultural Department. In case of any complaint by the member cultivator, the matter is settled amicably by the committee of the society. The members of co-operative societies have gained faith in their workers.

The merchants as well as the co-operative societies are very keen on maintaining the reputation of the quality of cotton in the tract. Before the produce is ginned, the yellow, stained *kapas* is removed. The produce of the last picking of immature cotton is ginned separately. Precautions are also taken that no free cotton seed or crushed seed is allowed to pass in the lint.

The lint is collected separately and pressed into half pressed bales where there are no direct pressing arrangements. Where there is a direct pressing arrangement the lint is collected in the *palla* house. After the bales are put into the finisher, the agmark labels are fixed below the three iron hoops at the flat corner of the bale. After the bales are removed from the press house, they are marked with press marks, the serial number of F. P. bales pressed during the season and the name of the society or the owner. The members of the society are given 75 per cent. of the estimated value of the *kapas* pooled at a fixed interest. The society disposes of the lint through the Union and re-sells the certified seed to the Department. The managing committee of the society is fully empowered to carry out all the sale transactions. After the end of the season which continues till June the society settles the account of each member. No fixed charges are, however, recovered for the sale of cotton from the members of the society, but on fixing the price, *pro-rata* deduction is made for expenditure incurred on ginning and handling of cotton. The co-operative cotton sale societies borrow money from the Central Co-operative Banks and advance loans to the members for cultivation and other purposes. Their Union at Surat works as a liasion body between the trader and the affiliated societies and finds buyers for the ginned and pooled cotton. It also tenders advice to the societies in regard to the selling of cotton at the proper time. The Union arranges for the audit of the member societies' accounts and also functions as an agent of the company insuring the cotton of the member society.

ECONOMICS OF COTTON PRODUCTION

Cotton is one of the main cash crops in the tract occupying about 40 to 50 per cent. of the area of a farmer's holding. The cost of cultivation varies according to seasonal conditions, which also affect the crop yield.

The details of the cost of cultivation per acre in the case of a peasant proprietor are given in Table 137.

TABLE 137. COST OF CULTIVATION OF COTTON PER ACRE

Item of cultivation	Labour Units		Bullocks	Cost
	Men	Women		
Total Cost:				Rs.
Preparatory tillage:				
(*a*) Removing stubbles of the previous crop	—	2½	—	1·72
(*b*) Harrowing (two)	1	—	2	4·00
Manuring:				
(*a*) Five cart loads of farm yard manure carting	2½	—	2	7·00
(*b*) Spreading manure	1	½	—	2·34
(*c*) Harrowing for mixing manure	½	—	1	2·00
Sowing (dibbling)	½	2½	—	2·72
Weeding (three times)	—	15	—	10·31
Thinning	½	—	—	1·00
Interculturing (five times)	3	2	6	13·37
Harvesting:				
(*a*) Picking of seed cotton 360 lb. per acre at Re. 1 per 40 lb.				9·00
Marketing				2·00
Cost of manure—five cart loads at Rs. 5 per cart load				25·00
Cost of seed five lb. at Rs. 5 per 40 lb.				0·63
Charges for implements				2·00
Land assessment				5·00
Interest on outlay at 6 per cent.				5·00
			Total	93·09
Total Receipts:				
Seed cotton 360 lb. per acre at Rs. 20 per maund of 40 lb.				180·00
Cotton stalks				2·00
				182·00
Net Profit: Rs. 182.00 *minus* Rs. 93.09=89.00 (rounded)				

Note: Man at Rs. 2 per day. Woman at Rs. 0·69 per day. Bullock at Re. 1 per day.

The farmer thus gets about Rs. 90 per acre under the present conditions of cultivation of cotton and the prevailing prices thereof.

SEED MULTIPLICATION AND DISTRIBUTION

Before an improved strain is recommended for general cultivation in the tract, its uniformity for morphological, economical and agricultural characters is well established. It is also tried on farmers' fields at various representative places in the tract for judging its relative superiority over the variety already under cultivation. Moreover, the produce of district trials is sent to the Technological Laboratory, Matunga, Bombay, for spinning tests and also to the mills. These preliminaries completed, the strain is taken up for seed multiplication and distribution with a definite plan to cover the entire area in a specified time. This is being done through seed multiplication and distribution schemes run by the State Governments with financial aid from the Indian Central Cotton Committee. The establishment consists of a cotton superintendent and necessary staff of agricultural officers and assistants to help him in the operation of the scheme.

For South Gujerat cotton tract, the selected strain is selfed on an area of three acres at the Agricultural Research Station, Surat, from which about 600 lb. of selfed seed is obtained. This selfed seed is grown on 70 acres, partly on the farm and partly on registered growers' area. This area is known as the nucleus area and gives about 350 Bengal maunds of seed. This seed is distributed to seven centres in the tract, to selected cultivators in a group of villages, each group representating a co-operative society. In all, it is grown on about 4,000 acres (by 250 cultivators), called the First Stage area. From each centre, the seed is further multiplied in that very locality, so that the societies become self-sufficient for seed distribution work, and the transport and other charges for handling the seed are minimised.

The resultant seed of the First Stage is further grown for multiplication, centre-wise, on the fields of 2,800 cultivators on an area of about 44,000 acres. This is called the Second Stage area. The area sown with the Second Stage resultant seed is called the Third Stage area, which extends to 3,30,000 acres, with 22,000 cultivators. The resultant seed of the Third Stage is more than sufficient to cover the remaining area of the tract, which is called the Fourth Stage area. With this plan, it is possible to cover the entire area of the South Gujerat cotton tract (about 6,50,000 acres) with the seed of the improved variety within a period of five years.

The seed of the nucleus area on the Government Farm is issued to farmers at the normal prevailing rate for growing the First Stage area. The resultant seed of the First Stage is purchased by the Department of Agriculture from different groups and societies, and through them it is sold to farmers for the Second Stage area on cash payment as directed by or in consultation with the Cotton Superintendent. The Second and Third Stage resultant seed is further distributed by the societies to their members and also to other societies if so directed by the Cotton Superintendent. This seed is sold on cash payment or on credit. If on credit, the amount is recovered when the produce is sold during the cotton season. The societies keep stage-wise records of the fields and the total area sown by each member cultivator. From the area list of the societies, the field inspection staff keeps the stage-wise record of purity percentage, and of the estimated and actual yield. The nucleus and the First Stage area is thoroughly rogued to remove any off-type plants. The Second and Third Stage area fields, up to five acres, are inspected by examining 100 plants, the rogues marked and the purity percentage recorded. In case of fields with more than five acres, for each additional acre, 20 more plants are examined.

Grading and Agmarking. This is being done as per grade specifications prescribed by the Agricultural Marketing Adviser to the Government of India. The produce of the nucleus area and of the First and Second Stages, having a purity rate of 98 per cent. and above, is given Agmark Pedigreed Labels (Red Labels) while that of the Third Stage area, having a purity rate of 97 per cent. and above, is given Agmark Certified Labels (Black Labels). For the produce of the Fourth Stage area certificates are issued when the purity rate is 95 per cent. and above. The agmark lables are placed on the full-pressed bales at the corner below the iron hoops. An agricultural assistant is posted at each ginning ad pressing factory to check and record the arrival of seed cotton under different stages. The prices realised for Agmark (Red Label), Agmark (Black Label) and Certified lots are on an average Rs. 25, Rs. 20 and Rs. 15 more per bale over the ordinary lot. Such grading and agmarking of cotton is greatly conducive to growing the approved variety in a pure form, so that the supply of uniform product to the cotton industry can be ensured. The scheme is now being operated on a basis of self-sufficiency. For every agmarked bale, the charge is Rs. 1.50 and for every bale certified for purity the charge is Re. 1. This charge comes to about 35 to 50 nP. per acre of cotton grown by the farmers.

UTILISATION OF COTTON SEED AND ITS PRODUCTS

Cotton seed is mostly utilised for sowing purposes and as cattle feed for milch cattle, specially baffaloes. The seed is used for feed either aftersoaking in water or after boiling. It is said to increase the fat percentage of milk. Cotton seed is also crushed for oil purposes. The percentage of oil in the local varieties varies from 18 to 22. The cake is fed to cattle and the oil is used for frying. The oil is also consumed by some mills for converting it into dehydrogenated oil.

COTTON LEGISLATION AND ZONES

For cotton legislation, the whole of the South Gujerat cotton tract consisting of the area lying south of the river Narmada, i.e., Ankleshwar *taluka* and

Rajpipla sub-division of Broach district, the whole of Surat district and Nawapur and Akkalkuwa *talukas* of West Khandesh district, is brought under one zone and declared as Protected Area.

The following Acts are current in this zone :

Cotton Transport Act, 1923. In order to maintain the quality and reputation of the cotton grown in the Protected Area, the Act prohibits :

1. The import of cotton into the Protected Area by rail, road, river or sea or by any one or more of such routes, save under and in accordance with the conditions of a licence prescribed in this behalf.
2. The delivery to and taking delivery by any person at any of the railway stations situated in the Protected Areas and specified in the schedule, of any cotton when such cotton has been consigned from a railway station not situated in the Protected Area unless such person holds the prescribed licence for the import by rail of cotton into the Protected Area.

Under the provisions of this Act, licences are being issued to *bona fide* traders and industrial concerns by the Director of Agriculture, Bombay State, for the import of cotton, cotton seed, lint, etc., for specified purposes only. The early application of the Act (1923) to the South Gujerat cotton tract proved to be very effective in preventing the further infiltration and in the elimination of the inferior cotton Goghari and thus maintaining the purity and reputation of the quality cotton 1027 A L. F.

Cotton Control Act, 1942. This Act prohibits the cultivation of types of cotton other than those approved by the State Department of Agriculture. It also prohibits the mixing of the prohibited variety of cotton with any of the other non-prohibited cottons.

Cotton Ginning and Pressing Factories Act, 1925. This Act prohibits the ginning and pressing of mixed varieties of cotton, watering of cotton and extra quantity of foreign material in lint. It also enforces the marking of full-pressed bales with a serial number and with the mark prescribed for the factory and also the submission of periodical ginning and pressing returns.

Cotton Statistics Act, 1946. Under this Act, every trader and every owner of a cotton factory in the State has to submit returns in prescribed forms giving the quantity of cotton in his possession on the last day of the season, i.e., August 31. Failure to submit such information is an offence under section 7 of the Act.

MIDDLE GUJERAT COTTON TRACT

The tract comprises the area lying between the river Narmada in the south and Sabarmati in the north, and includes a part of Broach district, the whole of Baroda, Kaira, Panch Mahals and Sabarkantha districts and a part of Ahmedabad district. The area under cotton in the tract is nearly 10,00,000 acres, producing about 3,00,000 bales annually. Cotton is the most important cash crop occupying as it does the first position in the rural economy of most of the tract.

SOILS AND CLIMATE

The soils of the tract vary from medium to deep black and *goradu* to sandy *goradu* loams. The main soil type in Middle Gujerat, on which cotton is extensively grown, is the typical deep black cotton soil. The soils in Broach and a portion of Baroda districts are typical black cotton soils and crack heavily on drying. They are highly retentive of moisture and are able to support a good cotton crop with a life period of about nine months. Cotton is also grown on *goradu* soils found in Jambusar *taluka* of Broach district, part of Baroda district and Kaira and Sabarkantha districts. The soils in some parts of Sabarkantha district are shallow, medium black and slopy. The *goradu* soils are deep and distinctly sandy, varying from the drift sands of Ahmedabad to the rich loams of Kaira. They vary in colour from light ash to rich brown and do not crack like the black soils of Broach. They are well drained and not so very moisture-retentive. Considering the soil-climate complex, the tract can be sub-divided into two natural zones: (*i*) Narmada-Mahi zone, i.e., the area lying between the rivers Narmada and Mahi; and (*ii*) Mahi-Sabarmati zone, i.e., the area lying between the rivers Mahi and Sabarmati.

The rainfall of the conventionally known Broach tract, the Narmada-Mahi zone, ranges from 30 to 45 inches, the average for the last 10 years as recorded at Broach being 34 inches (Table 138). During the last 25 years, all the seasons were more or less normal except 1948-49 and 1951-52, when the total rainfall was 11.4 and 15.5 inches, respectively. In contrast, the seasons 1942-43 and 1954-55 were characterised by abnormally high rainfall, 57.9 and 55.5 inches, respectively. As we proceed northwards, the rainfall in the Mahi-Sabarmati zone decreases. It ranges between 40 and 25 inches, the seasons being characterised by periodical droughts and much greater irregularity, both for the total amount received and for its distribution. The temperature ranges from 42°F. minimum in December-January to 112°F. maximum in May as recorded at Broach (Table 139). The seasons 1933-34 and 1934-35 were marked by frost resulting in a general reduction in yield (to the extent of 60 per cent.) and fall in the quality of the produce. The winters are comparatively less severe in the Narmada-Mahi zone than in the Mahi-Sabarmati zone. In the latter zone, the occurrence of frost is more frequent. The climate in the Narmada-Mahi zone is moderate, while that in the Mahi-Sabarmati zone gets drier as we proceed northwards.

IMPROVED VARIETIES

The cotton originally grown in the tract was known as Broach Desi. It had a reputation for its superior quality and was the basis of

TABLE 138. MONTHLY DISTRIBUTION OF RAINFALL FOR THE LAST 10 YEARS, FROM 1946-47 TO 1955-56, AT THE AGRICULTURAL RESEARCH STATION, BROACH

Crop season	June	July	August	September	October	November	December	April	Total
	Inches cents	Inches cents	Inches cents	Inches cents	Inches cents	Inches cents	Inches cents	Inches cents	Inches cents
1946-47	15-54	10-38	10-39	7-97	0-3	2-96	0-13	3-80	51-20
1947-48	0-8	15-18	11-15	17-3	0-91	0-0	0-0	0-0	44-35
1948-49	1-43	3-87	4-8	0-5	0-16	1-82	0-0	0-0	11-41
1949-50	0-0	10-74	7-1	8-5	1-20	0-0	0-0	0-0	27-0
1950-51	0-10	25-26	3-20	10-84	0-0	0-0	0-0	0-0	39-40
1951-52	1-19	10-88	2-36	0-8	0-0	0-0	0-0	0-0	14-51
1952-53	8-41	15-39	3-63	0-86	0-0	0-0	0-0	0-0	28-29
1953-54	4-28	10-48	16-88	4-61	0-11	0-0	0-0	0-0	36-36
1954-55	10-49	14-53	3-86	26-25	0-33	0-0	0-0	0-0	55-46
1955-56	4-34	5-46	11-20	10-98	1-64	0-0	0-0	0-0	33-62
Average	4-59	12-22	7-38	8-67	0-44	0-48	0-01	0-38	

TABLE 139. AVERAGE MONTHLY TEMPERATURES (MAXIMUM AND MINIMUM) FOR 5 YEARS, FROM 1951-52 TO 1955-56, AT THE AGRICULTURAL RESEARCH STATION, BROACH (degress F.)

Month	1951-52		1952-53		1953-54		1954-55		1955-56	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
June	100	76	96	75	101	76	99	79	100	77
July	95	76	86	72	90	80	90	77	95	78
August	88	73	80	71	84	73	89	76	90	76
September	96	73	89	70	88	72	85	73	90	77
October	97	71	94	65	93	68	90	66	89	70
November	92	62	87	55	89	56	89	58	87	55
December	84	52	84	53	85	52	84	50	84	53
January	84	51	80	51	83	50	84	54	84	54
February	87	56	91	56	90	59	92	59	90	56
March	94	61	100	64	99	65	101	68	100	66
April	103	70	106	70	107	73	103	70	108	72
May	105	75	103	74	109	80	108	76	106	77

the Indian Cotton Contract. However, the reputation of this cotton fell due to the intrusion and spread of the high ginning but short stapled, poor quality cotton, Goghari. Moreover, the Goghari variety was susceptible to the wilt disease of cotton which slowly spread in the tract. Hence, the combating of this disease also became a special problem for the successful cultivation of cotton in the tract. Thus, by the beginning of the present century, Broach cotton became an admixture of Broach Desi and Goghari in varying proportions, the average composition being 70 per cent. Goghari and 30 per cent. Broach Desi. Because of such high proportion of Goghari, the Broach Local cotton, though characterised by a high ginning outturn of 40 per cent., had short, rough and coarse fibres, capable of spinning only up to 15's highest standard warp counts. Besides, it was highly susceptible to the wilt disease of cotton. It was known as Kanmi cotton, because the tract round about Broach is called Kanam.

Early attempts (1914 to 1919) to improve cotton were for selecting from the Broach Local cotton, pure high ginning Goghari strains, for it was then felt that the cultivation of high ginning Goghari types might bring in more profit to the farmer. As a result, six Goghari strains were isolated (Patel, 1921) and are being maintained pure. But none of the Goghari strains was of immediate use for general cultivation; for, though they were characterised by very high ginning outturn (42 per cent. to 47 per cent.), they had very poor fibre qualities and lacked resistance to the wilt disease of cotton. Fortunately, however, attempts to select high yielding and better quality strains from the original Broach Desi variety resulted in the isolation of three strains, of which the strain Broach Desi 8 was found to be the best as it had a unique combination of high degree of wilt resistance and high spinning value up to 40's H.S.W.C. But this strain had a low ginning outturn, it being nearly seven per cent. less than Broach Local cotton. In Broach tract and even elsewhere, the price of seed cotton is generally fixed on the ginning outturn. The low ginning outturn of strain B. D. 8 was thus considered to be a defect for, inspite of its superior quality, it could not compensate sufficiently for this shortcoming. In fact, strain B. D. 8 was given out for general cultivation in the tract in 1936 but this defect proved to be an impediment in its spread. The results of trial of B. D. 8 and Broach Local are given in Table 140.

TABLE 140. COMPARATIVE PERFORMANCE OF B. D. 8 AND BROACH LOCAL, FROM 1932-33 TO 1935-36, AT THE AGRICULTURAL RESEARCH STATION, BROACH

Type	Yield of *kapas* (lb. per acre)	Ginning percentage	Fibre length (inch)	Fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.)	Total wilt attack (per cent.)
B. D. 8	609	32·6	0·89	0·163	37	3·6
Broach Local	505	39·1	0·80	0·184	16	73·3

In the early attempts (1925 to 1931) to evolve by hybridisation a strain with the required combination of wilt resistance, high ginning outturn and better staple qualities, several crosses were made involving Comilla, Wagale (*G. arboreum*), and Jayawant, B. D. 6 and B. D. 8 (*G. herbaceum*) as wilt-resistant parents. As none of these crosses yielded any promising segregates, they were rejected during the investigation.

The research work of selection and hybridisation did not give, till 1931, any all round strain of economic value. However, the pure types, viz., high ginning Goghari strains, like G. A. 26, and the wilt-resistant and superior quality Broach Desi strains, particularly B. D. 8, proved to be very valuable for further attempts at cotton improvement by hybridisation.

Development and Progress of Work from 1932. In 1932, the Bombay Department of Agriculture, with the funds of the Indian Central Cotton Committee, launched a scheme called the 'Broach Cotton Breeding Scheme' for the improvement of Broach cotton. The object of the scheme was to evolve by straight selection from local cotton or by hybridisation, a strain possessing a high degree of wilt resistance, a high ginning outturn and superior quality with a satisfactory yielding capacity, to replace the high ginning but wilt susceptible and poor quality Goghari mixture prevalent in the tract. A large-scale programme of selection from the local cotton and hybridisation was undertaken. Of the several selections made from the local cotton, none came up to the required standard of combination of desirable economic and agricultural characters. Side by side, crosses were made between B. D. 8 and the high ginning Goghari types and also types from outside the tract. Of the several crosses and backcrosses handled, the backcross (B. D. 8 × G. A. 26) × B. D. 8 gave two more or less similar sister strains named B. C. 1-2 and B. C. 1-6. They possess the desired combination of various characters, that is, satisfactory yield with a high degree of wilt resistance of B. D. 8, a high ginning outturn of 40 per cent. (i.e. as high as in local cotton) and superior fibre qualities of B. D. 8, with spinning capacity of 38's to 40's H.S.W.C. as against 14's of the local cotton. Both these segregates were thoroughly tried on the Government Farm at Broach and on cultivators' fields in the district and were found to surpass B. D. 8 and Broach Local cotton in monetary return per acre. The results of comparative trial of B. D. 8, Broach Local, B. C. 1-2 and B. C. 1-6 are given in Tables 141 and 142. With this distinct achievement, a 50:50 mixture of these two strains had been released for general cultivation in 1943 under the name of Vijay. Later, in 1946, Segregate B. C. 1-2 was found to be better of the two as a result of comparative trials and tests and hence it was finally selected to replace the mixture of the two sister strains, retaining the original name Vijay (Patel, 1947). Vijay is highly appreciated both by the farmers and the traders, and it has occupied a place of prominance in the textile industry of the country. By growing Vijay, the farmer gets an extra income of Rs. 15 per acre as compared to the local cotton and Rs. 20 per acre as compared to B. D. 8.

TABLE 141. COMPARATIVE PERFORMANCE OF B. C. 1-2, B. C. 1-6, B. D. 8 AND BROACH LOCAL (AVERAGE OF 3 SEASONS), FROM 1937-38 TO 1939-40, AT THE AGRICULTURAL RESEARCH STATION, BROACH

Segregate	Yield of *kapas* (lb. per acre)	Yield of lint (lb. per acre)	Ginning percentage	Fibre length (inch)	Fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.)
[(B. D. 8×G. A. 26)×B. D. 8]						
—1-2	571	231	40·5	0·89	0·167	39
” —1-6	592	247	41·8	0·88	0·170	39
B. D. 8	567	193	34·0	0·90	0·181	40
Broach Local	585	235	40·2	0·77	0·214	14

TABLE 142. AVERAGE PERFORMANCE OF SEGREGATES B. C. 1-2 AND B. C. 1-6 IN COMPARISON WITH B. D. 8 AND BROACH LOCAL IN BROACH DISTRICT] DURING SEASONS 1940-41 TO 1942-43

Type	Mean yield of *kapas* (lb. per acre)	Ginning percentage	Mean yield of lint (lb. per acre)	Staple length (inch)	Fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.)
B. C. 1-2-(Vijay)	458	38·9	178	0·86	0·162	30·6
B. C. 1-6-(Vijay)	465	39·3	182	0·87	0·163	30·3
B. D. 8	461	31·6	145	0·87	0·180	31·1
Broach Local	442	38·9	175	0·76	0·212	16·9

Vijay spread easily and rapidly, not only in what was conventionally known as the Broach tract, but throughout the Middle Gujerat tract of about 10,00,000 acres.

Since the release of Vijay for cultivation on a large-scale in 1943, work was continued to effect further improvement in fibre qualities to escape frost which periodically occurs in the northern part of the tract. Of the several crosses and backcrosses made for improving the quality, backcross (B. C. 1-2 × 1027 A L. F.) × B. C. 1-2 gave a type named 98-41, which on extensive trials was found to compare favourably with Vijay (Tables 143 and 144). It is as highly resistant to wilt as Vijay, yields about five per cent. more than Vijay, and has a good ginning outturn. It has slightly longer and finer fibres than Vijay and gives better spinning value and higher valuation. Moreover, it matures earlier than Vijay by about 10 days. Thus the object of improving Vijay for fibre qualities has been realised to some extent. Strain 98-41 has been found to give an extra income of Rs. 10 to Rs. 12 per acre over Vijay (Thakar, 1955). This strain has been released for general cultivation (replacing Vijay) in the Middle Gujerat tract under the name Digvijay from 1955-56. Promising synthetic material is available from the cross (E. 22 × 1802) and its backcross with E. 22 strain. Strain E. 22 is derived from the backcross (B. D. 8 early × B.C. 1-6) × B. C. 1-6. It is earlier than Vijay by about 25 days. Strain 1802 is a fine, long staple (full one inch) synthetic culture from Surat, derived from the backcross (1027 A L. F. × Iranian *herbaceum*) × 1027 A L. F.

From the cross of E. 22 × 1802, Culture No. 92 is particularly promising, having a fibre length of full one inch with good fibre strength, though with slightly lower ginning percentage than Vijay. Similar additional promising material is also available from the backcross (E. 22 × 1802) × E. 22 possessing staple length of full one inch, with a somewhat lesser yield and a lower ginning outturn than Culture No. 92. These cultures are earlier than Vijay by about a fortnight. They are being further worked upon.

The northern region of the tract has less retentive soils and often frost also occurs. Breeding work for this region has, therefore, been taken up at a sub-station at Kadiadra in Sabarkantha district from 1953-54, to evolve frost-resistant, early types which will in no way be inferior to Digvijay in quality. Early types from Broach, Indo-American types evolved at Surat through interspecific hybridisation, and outside *hirsutum* types are being studied to judge their suitability for this region.

COTTON CULTIVATION

Preparation of Land and Sowing. In the black soil, the preparatory tillage consists of two or three harrowings with a heavy blade-harrow and levelling with a plank. In *goradu* soils, no preparatory tillage before rains is possible as the surface is too hard to work on with an implement. So the

Table 143. Comparative Performance of Types 98-41 and Vijay, Average of Seasons from 1949-50 to 1951-52, at the Agricultural Research Station, Broach

Type	Yield of *kapas* (lb. per acre)	Ginning percentage	Fibre length (inch)	Fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.)	Resistance to wilt disease
98-41	775	38·9	0·89	0·157	43·0	Inter resistant to wilt
Vijay	755	39·3	0·87	0·174	38·3	„

Table 144. Average Performance of Vijay and 98-41, from 1957-58 to 1954-53, in the District

Type	Yield of *kapas* (lb. per acre)	Ginning percentage	Yield of lint (lb. per acre)	Fibre length (inch)	Fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.)
Vijay	481*	39·3	192	0·89	0·166	39
98-41	503*	39·0	199	0·91	0·154	42

Note: 98-41 matures earlier than Vijay by 10 days. It is also highly wilt resistant.

*The figures are the averages of 23 tests in different seasons at different places.

land is harrowed once or twice after the first showers of rain and levelled. In the black soils or in other cases where good mulch is available, sowing is generally done in dry mulch from the second week of June onwards till the monsoon sets in. In case the first showers are favourable, this practice helps in the timely establishment of the crop. However, if the rains are scanty, and are followed by dry weather, the cotton sprouts dry up, necessitating the re-sowing of the crop. Cultivators, however, prefer to sow in dry mulch. If the first showers are continuous, the sowing gets unduly delayed due to inaccessibility of the soil. But by then the crop sown in dry mulch makes a good start and is easily established. The crop is mainly grown under rainfed conditions due to want of irrigation facilities and because the sub-soil water is generally brackish. The seeds are besmeared with cowdung and earth, and drilled through a seed-drill. Dibbling is followed in rare cases. The seed rate is eight to ten lb. per acre. The spacing between rows is four-and-a-half to six feet and even up to seven-and-a-half feet. The crop is thinned to a distance of one to two feet between plants. Weedings are generally scanty in the black soils, which present a remarkably clean appearance. In the case of *goradu* soils two or three weedings are required to be done. Five or six inter-culturings with a heavy blade-harrow till October constitute 'after tillage' operations. Because of these operations, a good friable mulch, four to five inches deep is maintained during the period of subsequent growth of the crop.

Rotations and Manuring. The fertility of the black soils is usually maintained by following a three-year rotation of cotton followed by *rabi jowar* or wheat followed by Lang (*Lathyrus sativus*). Two-year rotations of cotton-*jowar* or cotton-Lang are also common. A portion of the holding is also left fallow at certain intervals. In rare cases or when the prices are pretty high, cotton is followed by cotton. Where farm yard manure is available, it is applied in varying proportions of 5 to 10 cart loads per acre at an interval of three or four years. However, farm yard manure is generally scarce. During recent years, therefore, organic manures like groundnut cake and castor cake and artificial manures like sulphate of ammonia and manure mixture are being used in varying proportions (up to 40 lb. N per acre) for manuring of cotton, keeping in view the rainfall conditions and the irrigation facilities available. The crop responds well to irrigation and manuring, and with one or two irrigations supplementing the rains, yields as much as 1,600 lb. per acre against the average of about 400 lb. under rainfed conditions. Flowering usually commences by the beginning of November and the picking lasts from January to March.

DISEASES AND PESTS

The common diseases of cotton are Wilt and Root Rot.

Wilt. As stated earlier, Broach Local cotton was highly susceptible to wilt, the virulance of which varied with seasonal conditions, it being very low in dry years and very high in wet years. The improved strains evolved at Broach are all highly resistant to the wilt disease. In fact, wilt resistance is one of the requisite characters for a cotton strain to be recommended for general cultivation and hence even now all the promising strains are being tested for their resistance or otherwise under standard conditions at Poona.

Root Rot. This disease is found to occur in patches in *goradu* soils. The problem is acute in some parts of Baroda and work is under way to find out a suitable remedy. As for the other diseases and pests, those described under the section of 'South Gujerat Tract' occur in this tract also and the problems as well as the remedies are common to both the tracts.

HARVESTING AND YIELD

Cotton picking commences by the middle of January and lasts for about two months. The number of pickings is generally three or four. The method of harvest is by picking the seed cotton from open bolls on the plants. The picking begins from early morning and continues till late in the evening. However, the best time for picking is the morning. When dew has fallen the seed cotton can be picked clean as bits of dry leaves and bracts, being moist, do not get mixed with the produce. Generally, cotton is picked on a contract basis, the rate being fixed per maund of 40 lb. of seed cotton picked. One labourer, on an average, picks about 40 to 50 lb. of seed cotton per day. The yield of seed cotton per acre is about 400 lb., giving about 150 lb. of lint.

MARKETING AND GINNING

The cultivators generally sell their produce in the form of *kapas* (seed cotton) to gin-owners. Of late, however, several co-operative societies have been formed by the cultivators themselves. The marketing of cotton is done through the following agencies.

Agricultural Produce Market Committee. Sixteen Agricultural Produce Market Committees function at present in the Middle Gujerat cotton tract : Broach, 2; Baroda, 2; Kaira, 4; Panch Mahals, 4; Sabarkantha, 3; and Ahmedabad, 1.

The seed cotton is purchased by traders in open auctions in the market yards. The interference of the middlemen is thus minimised in this system.

Cotton Sale Societies and Groups. There are, at present 38 Co-operative Cotton Sale Societies and 15 Co-operative Cotton Sale Groups, working in the Middle Gujerat cotton tract. The members of the societies are given the pool price of seed cotton fixed finally after deducting all the expenses.

The remaining produce is still being marketed by the old system through the middlemen and brokers where there are no Agricultural Produce Market Committees or Co-operative Cotton Sale Organisations. In this case, the cultivators actually realise much less, the profit being partially shared by the middlemen and brokers.

ECONOMICS OF COTTON PRODUCTION

The cost of cotton cultivation works out to about Rs. 90 to Rs. 100 per acre. The normal yield is about 400 lb. of seed cotton per acre from which, at the prevailing prices, the realisation will be about Rs. 180 to Rs. 200. This leaves a margin of Rs. 90 to Rs. 100 to the farmer from one acre of cotton. As stated earlier, yields, as high as 1600 lb. per acre, can be had by intensive cultivation. This will certainly leave a much higher margin of profit.

SEED MULTIPLICATION AND DISTRIBUTION

The multiplication and distribution of seed of improved varieties of cotton, viz., Vijay and Digvijay is being carried out under the Scheme for Multiplication and Distribution of Vijay cotton seed in Middle Gujerat.

Nucleus seed produced on the Government Farm, Broach, is grown under the First Stage on the fields of selected progressive growers. The multiplication up to four stages is being done through registered seed growers at a number of centres in the tract as in the case of the South Gujerat cotton tract for the production of certified seed and its further distribution. The area under four stages, which is called Reserved Area, is kept under the control of the Department, wherein inspection for purity and subsequently for roguing is carried out through a team of agricultural assistants and seasonal staff at the time of the boll-formation of the crop. The crop under the First and Second Stages is rogued out completely and made 100 per cent. pure. The crop which attains the required standard of purity, viz., 95 to 100 per cent. is certified by the department. The certified seed cotton is pooled at approved gins separately and heaped stage-wise. The ginning and pressing, and agmarking or certification is done under the close supervision of the department. The resultant seed is also heaped stage-wise. The certified seed up to the Fourth Stage is distributed to registered seed growers for growing on Reserved Area under the control of the department through the agencies of the co-operative societies, groups and approved agents of the department. The resultant certified seed from the Fourth Stage seed cotton is distributed to the cultivators of General Area through approved agents, appointed by the department.

The stages under organisation and their respective purity standards are given in Table 145.

Thus, a Reserved Area of about 1,50,000 acres is raised every year, so that the resultant seed from this area may suffice to feed the General Area of the whole cotton tract of Middle Gujerat.

UTILIZATION OF COTTON SEED AND ITS PRODUCTS

The cotton seed is mainly used for sowing and as cattle feed in this tract.

Table 145. Standard of Purity Under Different Stages

Stage	Area scheduled to be maintained (acres)	Purity percentage	Agmarking and Certification of full pressed bales
Nucleus	4	100	Agmark certified Pedigreed (Red Label)
First	100	100	
Second	1,300	100	
Third	14,000	97-98	Agmark certified (Black Label)
Fourth	1,35,000	95-97	Certified

COTTON LEGISLATION AND ZONES

The following Acts are operating at present in this tract of the Narmada-Sabarmati zone of Middle Gujerat.

1. The Bombay Cotton Transport Act, 1923.
2. The Bombay Cotton Ginning and Pressing Factories Act, 1925.
3. The Bombay Gotton Control Act, 1942.
4. The Bombay Cotton (Statistical) Act, 1946.

NORTH GUJERAT COTTON TRACT INCLUDING NORTH SAURASHTRA AND KUTCH

The tract consists of :(*i*) North Gujerat area, lying to the north-west of the Sabarmati River comprising part of Ahmedabad district, Mehsana and Banaskantha districts; (*ii*) Saurashtra, excluding the south-east tract of Mathio cotton; and (*iii*) the eastern part of Kutch known as Wagad, mainly Bhachau and Rapar *talukas.*

The cottons under cultivation in this tract are commercially known as Dholleras, comprising three varieties locally called Wagad, Lalio and Mathio, the former two belonging to the *herbaceum* group and the latter to the *arboreum* group of cotton. The total area under Dholleras is estimated to be about 19 lakh acres of which about 15 lakhs is under Wagad. The estimated production of Wagad is about four lakh bales. Wagad cotton is a hardy type of *herbaceum* cotton and is characterised by dense habit of growth with few vegetative branches. On account of this feature, it shows a good bearing capacity in proportion to the growth. A special feature of this variety is that the bolls when ripe open but slightly, and consequently the harvesting of the crop is done by picking ripe bolls bodily from the plants and marketing as such.

SOIL

The soil of the tract is of alluvial formation, believed to have been derived from granite and gneissic rocks of Rajputana and Central India. The alluvium itself gives the impression of having been deposited either on the edge of the sea or in brackish water. The soils on which Wagad cotton is grown can be classified into three categories, viz.,: (*i*) reddish *goradu*; (*ii*) medium black, locally known as *basar*; and (*iii*) typical black cotton soil. The soils are greatly varying in depth, and somewhat saltish in nature, which is much more marked in North Saurashtra and Kutch. The sticky character of the black soil of South Gujerat is largely absent. Where the land is clayey, it is not slimy as that of Surat soils. Thus, the characteristic soils of Wagad cotton may be described as an alluvial silt of a heavy to light character with a fair content of lime and distinctly salty.

CLIMATE

The climatic conditions under which Wagad cotton is grown represents the driest conditions in the whole of India, where cotton is cultivated as a rainfed crop. There is a wide variation in the average annual rainfall from locality to locality in North Gujerat, which ranges from 19 inches at Viramgam, 25 inches at Dholka-Bavla and 23 inches at Jagudan-Vijapur, as shown in Tables 146a, 146b, and 146c. In Saurashtra, it ranges from 15 to 25 inches, while in Kutch it is nearly 14 inches. The behaviour of monsoon in the tract is very erratic and even within the same locality and seasons there is a wide variation in the amount of rainfall, ranging from 5 to 50 inches at Viramgam, 10 to 59 inches at Dholka and 8 to 59 inches at Jagudan in North Gujerat, with similar variation in Saurashtra and Kutch. The rainfall is limited to the months from June to October and decreases towards west of the tract. The absolute maximum and minimum temperature is 119°F. in May and 36°F. in January, respectively. The mean temperature during the growth of the crop is higher than in other parts of Gujerat, while it is lower during flowering and boll production. The occurrence of frost in the tract is common at an interval of three to four years. The characteristic feature of Wagad cotton growing areas is the low humidity of the atmosphere during a large part of the growing season, as compared to that in any other parts of Gujerat. The climatological data on rainfall, temperature and humidity as recorded at Viramgam, a representative place of the tract and also those at Bavla and Jagudan are given in Tables 146a, 146b, 146c, 147a, 147b, 147c and 148.

IMPROVED VARIETIES

The *herbaceum* cotton Wagad which is chiefly grown in North Gujerat, Saurashtra and Kutch forms the chief and important constituent of the commercial cotton known as Dholleras. It is a very hardy variety; adapted to a tract, wherein the behaviour of the monsoon is very erratic, the distribution of rainfall is very uneven often resulting in droughty conditions, where frost occurs once in three or four years and where the soils are rather of saltish nature. The chief characteristic feature of Wagad cotton is that the bolls open

TABLE 146(a). YEARLY AND MONTHLY RAINFALL AT VIRAMGAM, FROM 1946 TO 1955

Year	Month												Total
	January	February	March	April	May	June	July	August	September	October	November	December	
1946	—	—	—	—	—	6·11	6·02	4·44	0·10	—	0·53	0·29	17·49
1947	—	—	—	0·94	0·57	—	3·02	5·79	3·87	0·11	—	—	14·30
1948	0·56	—	—	—	—	0·10	0·73	2·17	0·78	1·16	—	—	5·50
1949	—	—	—	—	—	0·76	8·73	3·28	4·12	—	—	—	16·89
1950	—	—	—	—	—	0·09	9·58	4·02	10·68	—	—	—	24·37
1951	—	—	—	—	—	0·46	6·98	2·27	—	—	0·69	—	9·80
1952	—	—	—	—	—	1·74	9·97	3·68	0·16	—	—	—	13·55
1953	0·84	—	—	—	0·19	0·65	7·96	26·15	2·48	—	—	—	38·27
1954	—	—	0·61	—	—	1·96	6·00	4·16	12·26	2·85	—	—	27·84
1955	—	—	—	—	0·09	3·38	1·04	6·23	9·46	0·07	—	—	20·27
Average	0·14	—	0·06	0·09	0·09	1·52	5·80	6·22	4·39	0·42	0·12	0·03	18·88

TABLE 146(b). YEARLY AND MONTHLY RAINFALL AT BAVLA, FROM 1944 TO 1953

Year	Month												Total
	January	February	March	April	May	June	July	August	September	October	November	December	
1944	—	—	—	—	—	5·03	16·92	17·64	3·59	—	—	—	43·18
1945	0·14	—	—	—	0·24	3·31	13·37	10·58	8·39	0·37	—	—	36·40
1946	—	0·02	—	0·04	0·06	13·03	5·81	12·39	0·32	—	0·54	0·50	32·71
1947	—	—	—	2·06	—	1·18	12·86	6·99	5·18	0·39	0·03	—	28·69
1948	0·63	—	—	—	0·10	1·05	2·86	4·90	2·99	0·05	0·34	—	12·92
1949	—	—	—	—	—	1·06	10·32	7·47	3·45	0·42	1·53	—	24·25
1950	—	—	—	—	—	0·24	14·42	3·05	6·56	—	—	—	24·27
1951	—	—	—	—	—	0·81	4·42	4·29	0·15	—	0·09	—	9·76
1952	—	—	—	—	—	4·31	7·95	4·11	0·59	—	—	—	19·96
1953	0·60	—	—	—	1·00	2·74	5·48	24·38	5·28	—	—	—	39·48
Average	0·14	—	—	0·21	0·14	2·78	9·44	9·58	3·65	0·12	0·25	0·05	27·16

TABLE 146(c). YEARLY AND MONTHLY RAINFALL AT JAGUDAN, FROM 1944 TO 1953

Year	Month												Total
	January	February	March	April	May	June	July	August	September	October	November	December	
1944	0·13	—	—	—	—	6·32	15·50	12·35	0·19	—	—	—	34·49
1945	0·16	—	—	—	0·04	2·10	11·19	10·03	2·55	—	—	—	26·07
1946	—	0·04	—	—	0·64	6·18	7·15	4·63	0·20	—	—	0·36	19·20
1947	—	—	—	0·09	—	—	3·09	5·13	4·33	0·59	—	—	13·23
1948	0·53	—	—	—	—	0·08	2·34	8·87	0·66	0·38	—	—	12·86
1949	—	—	—	—	—	0·11	5·12	3·17	2·60	0·52	0·32	—	11·84
1950	—	—	—	—	—	—	19·52	2·98	18·71	—	—	—	41·21
1951	—	—	—	—	—	0·85	4·90	5·16	—	—	—	—	10·91
1952	—	—	—	—	—	3·97	19·88	4·89	—	—	—	—	28·74
1953	0·86	—	—	—	—	0·75	4·71	25·34	2·66	—	—	—	34·32
Average	0·17	0·0	—	0·0	0·07	2·03	9·34	8·25	3·19	0·15	0·03	0·04	23·29

TABLE 147(a). AVERAGE MONTHLY MAXIMUM AND MINIMUM TEMPERATURE AT VIRAMGAM, FROM 1946 TO 1955

Year	Month											
	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1946	82·5	58·1	91·8	66·5	95·6	71·1	107·8	82·4	105·0	84·0	100·8	84·7
1947	81·1	65·9	88·3	64·5	96·8	75·5	100·9	81·0	108·2	86·1	105·2	87·8
1948	78·5	61·2	83·8	68·8	93·0	76·8	105·7	83·7	108·5	87·6	104·8	87·2
1949	81·5	65·0	87·9	66·4	99·8	74·6	108·1	81·6	106·5	86·8	105·0	86·9
1950	85·4	54·8	82·8	49·8	96·1	62·8	104·7	70·7	108·2	78·9	105·5	82·1
1951	82·3	49·4	88·1	52·7	96·4	65·0	100·7	71·2	109·6	78·6	104·7	82·2
1952	87·7	52·7	91·1	58·6	98·1	63·2	105·5	75·0	109·7	81·2	103·1	82·2
1953	81·7	56·1	93·3	61·3	101·9	57·1	105·1	74·3	106·2	79·5	104·4	82·2
1954	82·5	49·7	89·3	58·9	98·0	65·7	105·5	73·9	109·6	78·9	103·4	82·1
1955	83·2	53·7	89·8	58·0	100·7	67·0	102·4	67·5	108·6	78·1	102·4	81·1

Year	Month											
	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1946	90·3	81·5	98·9	79·3	96·4	79·3	100·5	79·9	88·0	68·0	82·1	62·1
1947	96·2	83·6	95·4	83·0	91·4	80·0	94·3	75·6	90·1	71·8	84·3	62·6
1948	97·8	85·6	93·5	82·3	95·0	81·9	98·5	82·1	90·0	71·2	84·2	64·1
1949	95·8	83·0	95·1	81·9	96·5	81·7	98·4	80·6	90·5	69·4	83·7	61·2
1950	89·9	77·8	91·8	75·8	92·4	75·7	96·6	67·2	90·5	55·4	82·7	48·9
1951	99·0	80·9	93·3	77·7	99·9	77·5	101·9	73·0	96·5	63·3	88·4	53·7
1952	95·1	79·3	90·2	76·7	94·7	74·5	99·8	71·4	93·3	59·7	86·7	56·3
1953	96·0	80·7	88·1	71·9	92·7	76·5	98·2	70·8	92·8	61·5	90·1	56·0
1954	93·6	78·9	92·6	76·6	89·8	75·4	94·1	67·0	92·1	58·0	85·7	51·5
1955	98·2	79·5	86·9	77·1	88·7	76·6	94·6	70·0	90·1	59·0	85·3	54·8

TABLE 147(b). AVERAGE MONTHLY MAXIMUM AND MINIMUM TEMPERATURE AT BAVLA, FROM 1948 TO 1953

Year	January		February		March		April		May		June		July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1948	—	—	—	—	—	—	100	89	102	92	99	91	94	91	90	85	89	83	92	85	90	80	81	75
1949	87	69	89	72	100	78	106	84	108	88	105	89	97	84	96	83	98	85	99	82	92	73	81	66
1950	85	67	87	63	96	72	106	83	108	86	105	88	90	81	94	82	94	82	95	84	93	69	83	63
1951	80	65	83	64	95	77	101	82	108	89	100	87	98	85	96	82	100	85	101	83	94	76	85	68
1952	83	67	88	72	97	78	105	86	108	89	102	83	93	83	90	80	96	84	99	83	92	73	84	67
1953	80	65	92	72	102	80	106	85	106	88	104	88	96	84	89	81	96	83	98	80	91	73	87	69

TABLE 147(c). AVERAGE MONTHLY MAXIMUM AND MINIMUM TEMPERATURE AT JAGUDAN, FROM 1944 TO 1953

Year	January		February		March		April		May		June		July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1944	80	50	83	55	92	64	100	70	106	78	100	80	86	77	86	77	90	75	94	68	88	58	85	55
1945	80	50	85	55	100	65	102	70	105	76	105	80	86	78	88	77	90	75	94	66	90	55	80	48
1946	82	52	90	58	95	65	105	75	105	80	100	80	90	78	88	77	92	72	98	70	*	*	84	55
1947	82	52	84	58	*	*	100	72	110	77	103	82	95	78	95	78	86	74	92	62	90	60	95	52
1948	78	55	85	55	95	65	105	72	110	80	103	82	98	80	90	77	93	75	97	72	90	62	85	52
1949	85	53	85	55	96	62	106	68	109	77	103	80	92	77	92	76	90	74	98	70	92	58	84	52
1950	82	52	82	47	94	60	106	68	106	77	103	79	85	74	88	74	90	72	94	64	89	54	84	47
1951	80	45	85	45	95	62	101	68	107	74	102	78	95	78	88	74	94	73	97	74	96	64	84	52
1952	82	50	86	52	92	64	106	72	108	78	104	80	90	76	85	74	90	72	95	70	90	60	84	55
1953	80	48	85	55	100	65	105	76	105	76	106	78	95	75	85	75	88	76	96	70	90	60	87	56

TABLE 148. MONTHLY HUMIDITY PER CENT. AT VIRAMGAM, FROM 1951 TO 1955 (read at 7-30 hours)

Year	Month					
	January	February	March	April	May	June
1951	65	63	65	58	77	75
1952	52	53	50	65	65	75
1953	78	56	71	54	73	76
1954	61	68	53	63	74	76
1955	31	51	59	43	57	75

Year	Month					
	July	August	September	October	November	December
1951	84	90	78	70	50	53
1952	87	91	84	66	58	58
1953	86	93	89	59	56	62
1954	89	91	92	75	70	61
1955	81	91	93	68	57	63

slightly when ripe and are consequently picked bodily from the plant and marketed as such. The staple length is 3/4 inch to 7/8 inch and the fibre is thick and coarse. Commercially, it is known as good-bodied cotton which is of special advantage in sizing.

Improvement by Selection in Wagad Cotton. The work of selection in Wagad cotton was originally started at Broach in 1917-18, by the Department of Agriculture, Bombay, from the crop grown from seed samples obtained from some localities in Ahmedabad district. It consisted of the isolation of types with different botanical characters, purifying them, studying their growth behaviour and recording their performance for economic characters. Five strains, viz., Wagad Nos. 4, 8, 12, 14 and Wagad White Flower were isolated. The work was permanently shifted to Viramgam (chief representative place of the Wagad tract) where the study of the types was continued as at Broach (Patel and Mankad, 1927). Of the five strains isolated, Wagad 8 was found to be superior to Local Wagad in the yield of seed cotton by 10 per cent. and in ginning outturn by three to four per cent. (39 per cent. of Wagad 8 *vs.* 36 per cent. of Local) and as such it was adopted as the standard strain. It did not represent an improvement in quality of fibre over the Local Wagad, the fibre length of Wagad 8 being 0.80 inch as against 0.82 inch of Local and the spinning value of Wagad 8 being 14's H.S.W.C. as against 15's of Local. From 1925-26 onwards, large-scale selections from Wagad cotton of North Gujerat, Saurashtra and Kutch were made, but none with an all round combination of the desired economic characters and showing a distinct superiority over Local Wagad or Wagad 8 could be obtained. In order to improve strain Wagad 8 for quality, it was crossed with quality cotton 1027 A L. F. (in 1926-27) and the F_1 was backcrossed to Wagad 8. From this backcross, a segregate named 4-1 was obtained which had the requisite close-boll character. This segregate (as well as many other segregates) had very high ginning outturn, even higher than the high-ginning parent Wagad 8. Ten years' average performance of Segregate 4-1 (Table 149) showed that it was superior to both Wagad 8 and Local Wagad in ginning outturn—42 per cent. for Segregate 4-1 against 39 per cent. for Wagad 8 and 36 per cent. for the Local Wagad. It was found to be as good as Local Wagad in the yield of seed cotton, but inferior to Wagad 8. However, on account of its very high ginning outturn, it was equal to Wagad 8 in lint yield per acre and was 20 per cent. higher than the Local Wagad in this respect. The quality of lint of this segregate suffered in years of deficient rainfall. On an average, it was found to be only slightly superior to Local Wagad in spinning value. Another segregate, named 7-1, was obtained from the straight cross of Wagad 8 × 1027 A L. F. This had a much wider opening of bolls than ordinarily found in Wagad cotton and hence inspite of its having a good combination of economic characters, it could not be taken up for general cultivation. Additional crosses of Wagad 8 with quality cottons from Surat and Broach were made. At this stage of research, the scope of work was greatly widened through a scheme for the improvement of Dholleras Wagad cotton at Viramgam, financed by the Indian Central Cotton Committee. The scheme came into operation during 1937-38, with the main station at Viramgam and with a small immune area protected by irrigation at Jagudan (Mehsana district) as a safeguard. It had for its object the improvement of Wagad cotton: (*i*) for quality and yield ; and (*ii*) for earliness to escape frost and to replace, if possible, the inferior Mathio cotton (grown in South Saurashtra) by an early *herbaceum*. During the earlier period of the scheme, the trials of Seg. 4-1 and Seg. 7-1 were continued. The trials confirmed the results of former ones. On an average, Seg. 4-1 gave an extra return of three to four rupees per acre over the Local Wagad. It was, therefore, released for general cultivation in 1942 under the name Wagotar. With the expanded programme for research, selection in Wagad cotton from various localities was continued. Additional plant material was also created consisting of crosses of Wagad types with : (*a*) Surti-Broach quality type; (*b*) early Russian *herbaceums*; and (*c*) long and fine staple close-boll *herbaceum* types from Iran. In most of the cases backcrosses and composite crosses were made with Wagad type with a view to getting as many desirable characters of Wagad cotton combined with the earliness or good quality of outside types.

As a result of large-scale selection and trial in Wagad cotton from various localities, a type named W.87 was isolated from Nawanagar (Saurashtra). This type was found to be distinctly superior to Local Wagad in all respects

TABLE 149. COMPARATIVE PERFORMANCE OF WAGAD 8, SEG. 4-1 (WAGOTAR) AND LOCAL WAGAD FOR 10 YEARS, FROM 1933-34 TO 1942-43

Season	Yield of *kapas* (lb. per acre)			Ginning percentage			Fibre length (inch)			Fibre weight per inch (10^{-6} oz.)			Spinning value (H.S.W.C.)		
	Wagad 8	Seg. 4-1	Local Wagad	Wagad 8	Seg. 4-1	Local Wagad	Wagad 8	Seg. 4-1	Local Wagad	Wagad 8	Seg. 4-1	Local Wagad	Wagad 8	Seg. 4-1	Local Wagad
1933-34	602	569	465	36·9	40·1	33·7	0·81	0·81	0·80	0·181	0·143	0·158	17	24	18
1934-35	733	657	718	43·1	46·4	38·3	0·79	0·80	0·83	0·250	0·201	0·218	14	20	16
1935-36	458	431	392	39·6	42·8	35·4	0·78	0·79	0·83	0·216	0·186	0·210	12	14	12
1936-37	117	62	91	34·0	36·9	29·8	0·81	0·76	0·78	0·221	0·171	0·187	13	15	19
1937-38	929	918	864	43·7	46·1	39·0	0·82	0·80	0·82	0·211	0·195	0·207	13	20	19
1938-39	518	448	478	38·0	41·6	34·8	0·80	0·80	0·78	0·270	0·208	0·223	12	13	11
1939-40	313	309	285	39·6	43·7	35·1	0·73	0·77	0·79	0·236	0·277	0·227	11	12	12
1940-41	170	159	157	33·4	37·5	30·5	0·70	0·67	0·67	0·214	0·197	0·217	11	9	10
1941-42	394	397	369	37·5	38·9	32·9	0·79	0·79	0·77	0·244	0·201	0·227	12	14	12
1942-43	843	743	753	42·9	45·5	39·2	0·79	0·75	0·79	0·238	0·225	0·238	11	13	10
Average	508	469	457	38·9	42·0	34·9	0·78	0·77	0·79	0·228	0·193	0·211	13	15	11

and also over Seg. 4-1 (Wagotar) except in ginning outturn which was lower by three to four per cent.

Out of the Surti-Broach group of crosses, several segregates were tried. Of these a segregate named K.72-2 was found to be very promising. It is derived from the cross of Wagad 8 × Surat type 22-3-1-3 backcrossed to Wagad 8. The Wagad 8 parent is very hardy, high yielding selection, isolated from Local Wagad and type 22-3-1-3 is a high spinner (40's to 45's H.S.W.C.) derived from the cross of Surat 1027 A L. F. × Jayawant (Kumpta type from Dharwar) known to be earlier than 1027 A L. F. by about a fortnight. The characteristic of Jayawant cotton of getting a large number of buds and flowers quickly even after shedding, due to cloudy or rainy weather, has been found to be very helpful in tiding over unfavourable weather conditions. This character has been inherited in K.72-2 to a certain extent, through Seg. 22-3-1-3 on account of which it maintains its good yielding capacity. The detailed trial of K.72-2 (Table 150) showed that it was distinctly superior to Local Wagad in all respects and also to Seg. 4-1 (Wagator) then under general cultivation. Although it had a somewhat lower ginning outturn than Wagotar, the yield of lint per acre was higher by about 10 per cent. on account of its higher yielding capacity.

TABLE 150. COMPARATIVE PERFORMANCE OF WAGOTAR, KALYAN AND LOCAL WAGAD (AVERAGE OF THREE STATIONS) FOR 5 YEARS, FROM 1946-47 TO 1950-51

Strain	Yield of *kapas* (lb. per acre)				
	1946-47	1947-48	1948-49	1949-50	1950-51
Wagotar	569	457	536	743	647
Kalyan (K.72-2)	626	535	608	828	764
Local Wagad	572	521	616	797	800

Strain	Mean	Ginning percentage	Fibre length (inch)	Fibre weight per inch (10^{-6} oz.)	Spinning value (H.S.W.C.)
Wagotar	590	41·4	0·83	0·197	21
Kalyan (K.72-2)	672	39·9	0·87	0·195	28
Local Wagad	661	37·0	0·83	0·222	17

Further, K.72-2 was valued higher than Wagotar by about Rs. 50 per candy. In mill tests also, it was found to give a stronger yarn than Wagad. From a practical industrial viewpoint, it was considered to be admirably suitable for 20's counts. With such an encouraging and unique performance of

K.72-2 cotton, it was given the popular name of Kalyan and was released for general cultivation during 1947 in place of Wagotar (Patel, 1949). The growers of Kalyan cotton realised an extra income of about Rs. 15 per acre.

As frost and drought are of common occurrence in the tract, breeding for earliness is of particular importance. Further, if a suitable early *herbaceum* cotton can be had, it may be possible to replace the inferior Mathio cotton, *G. arboreum* (grown only in South Saurashtra, in an otherwise homogeneous *herbaceum* tract), by an early *herbaceum*. With this end in view and to further improve Wagad cotton for quality, a good collection of *herbaceum* cottons from Russia and Iran was made available. Some early types from South India (open-boll forms) were also obtained. Most of the foreign types were close-boll forms and were of sympodial growth habit. Some of the Iranian *herbaceum* types were characterised by long, fine and silky fibre. By themselves, they were ill-adapted to the growth conditions at Viramgam, were poor in yielding capacity and had low ginning outturn. Again the character of earliness, arising out of the sympodial growth habit, was greatly modified on account of bud and boll shedding and by shorter or longer boll ripening period. These were, therefore, found to be unsuitable for direct cultivation. They were, however, used for hybridisation with the Wagad types. Some of the early ripening segregates from these crosses, though superior in fibre length, were found to be inferior in yield and ginning outturn. Thus, an all round strain, superior to Kalyan, could not be had from these crosses. Efforts made in the direction of evolving a very early type of *herbaceum* cotton having open bolls, with a view to replacing the inferior Mathio variety, resulted in the isolation of an early segregate 223 from the cross of Surat 1027 A L. F. × very early open-boll Russian type. But further efforts in this direction were dropped in view of the evolution of a superior improved strain of *arboreum* cotton, named Pratap, selected from the Mathio variety itself.

Under such hard, difficult and uncertain growth conditions for cotton in the tract, the aim of making further improvement in Kalyan cotton was restricted to evolving a type earlier than Kalyan to escape frost, while retaining all its desirable characters. Crosses between Kalyan and Russian types and early derivatives from Russian crosses such as 223 and H.8-1 were made. Out of the several early segregates tried, one segregate, viz., 280-1 is found to be promising in as much as it is distinctly earlier than Kalyan by about two weeks and has equally good quality of lint though it is somewhat lower in yield. This strain is being further tried in the district.

Fresh crosses between Kalyan and W. 87 on the one hand and early *herbaceum* types from Dharwar and Madras on the other have been made for evolving an earlier and higher yielding strain with Kalyan as the standard of comparision. Additional synthetic material is also on hand to further improve Kalyan for quality.

COTTON CULTIVATION

The usual rotation is a two-season one of cotton and *jowar* In some cases, cotton is rotated with *bajra* or wheat. In certain areas, cotton after cotton is grown for three or four years in succession, and then the rotation of *jowar* is begun. The preparatory tillage consists of two harrowings with a long harrow, given in summer before the commencement of the monsoon. In some parts, ploughing is done with a wooden plough after the first rains. The crop is sown at the first available opportunity after the breaking of the monsoon, which normally commences by the end of June or beginning of July, but in water-logged areas, the Wagad variety can be successfully sown even as late as September. Sowing is usually done by drilling in rows 15 to 25 inches apart with a three-coultered seed drill. The usual seed rate is about 15 lb. per acre. The crop is usually not thinned. Generally, the crop is not manured. But during recent years, progressive cultivators in certain areas are adopting improved methods like wider sowing, dibbling, manuring, irrigation, etc. The subsequent tillage consists of two or three interculturing operations with small blade-hoes during the early stages of growth. The weeding operation is done with the help of *khurpis* (weeding hooks). Irrigation is followed on a negligible area, where facilities are available and water and soil conditions permit. The period of flowering ranges from October to December. The crop is ready for harvest by February-March.

PESTS AND DISEASES

The following are the most harmful pests of cotton.

1. Spotted Bollworm (*Earias fabia and Earias insulana*)
2. Pink Bollworm (*Platyedra gossypiella* Saund.)
3. White Ant (Termites) attack in *gorat* soil; generally associated with Cotton Root Rot (*Macrophomina phaseoli*).

The minor pests are :

1. Cotton Stem Borer (*Sphenoptera gossypii* Horr.)
2. Cotton Aphis (*Aphis gossypii* Glov.)
3. Red Cotton Bug
4. Dusky Cotton Bug

For details, please refer to 'Pests and Diseases' Section under South Gujerat Cotton Tract.

The most common disease of cotton wilt found in other black soil tracts is not ordinarily noticed in this tract. But root rot disease of cotton is seen in certain *gorat* and sandy *gorat* areas.

HARVESTING AND YIELD

The crop is harvested in February-March by picking dry bolls bodily from the plants in one or at the most two instalments. The average yield per acre of the tract is about 350 lb. of *kalas* (dry bolls) which gives about 150 lb. of seed cotton or 90 lb. of lint. In Kutch, this yield is rather low, being about 70 lb. per acre.

MARKETING AND GINNING

The cotton cultivators sell their produce in the form of *kalas* to the cotton merchants through regulated markets functioning in the tract or directly through brokers. These merchants stock the *kalas* and get the *kapas* extracted by village labour at leisure at certain centres by issuing out *kalas* in small instalments of a maund (40 lb.) or two and receiving the extracted *kapas* therefrom. The operation is done by hand, by forcing open the valves of bolls and extracting *kapas* therefrom. This job is generally done by women. The charges for extraction per maund of *kalas* are fixed. The seed cotton is then ginned in the ginneries located at various places in the tract. If, however, the produce is sold by the cultivators in advance to the wholesale merchants, it is sent direct to the godowns of the factories for shelling, ginning and pressing. Petty merchants sell the lint in loose form to bigger merchants who get the bales pressed and sell them to the mill industry.

ECONOMICS OF COTTON PRODUCTION

The following are the various cultivation and other operations in cotton production (Table 151).

TABLE 151. COST OF CULTIVATION AND OTHER OPERATIONS IN COTTON PRODUCTION

Item of cultivation	Labour units			Cost per acre
	Men	Women	Bullocks	
Total Cost:				Rs.
Preparatory tillage:				
Harrowing with blade-harrow (twice)	1	—	2	4·00
Sowing:				
Drilling and covering	1	—	1	3·00
Weeding (twice)	—	8	—	6·00
Interculturing (twice)	2	—	2	6·00
Harvesting:				
Picking *kalas* (dry bolls)	—	4	—	3·00
Marketing	½	—	½	1·50
Cost of seed 20 lb. at Rs. 5 per 40 lb.				2·50
Charges for implements				2·75
Land assessment				2·25
Watching charges				1·25
Interest on outlay at 6 per cent.				5·00
			Total	37·25
Total Receipts:				
Kapas 360 lb. at Rs. 10 per md. of 40 lb.				90·00

Net Profit: Rs. 90·00 *minus* Rs. 37·25=52·75

The farmer gets about Rs. 50 per acre under the present conditions of cultivation of Wagad cotton and the prevailing prices thereof.

SEED MULTIPLICATON AND DISTRIBUTION

The selfed seed is produced at the Cotton Breeding Station, Viramgam. The multiplication of the nucleus (selfed) seed is done on the registered seed growers' fields, round about the headquarters of agricultural officers at the different centres and so also the multiplication of the First Stage seed. The multiplication of the Second and Third Stage seed is done in the district. The cotton area sown with nucleus, First, Second and Third Stage seed is the Reserved Area of the department. In the Reserved Area, roguing is done in the nucleus and the First Stage area. Inspection is done in the Second and Third Stage area by the staff for ascertaining the purity of the crop and recording the estimates. The produce of the Reserved Area is pooled and ginned under the close supervision of the departmental staff. The work of pooling, shelling, ginning, pressing and distribution of seed, of the improved variety Kalyan, is done through authorised licencees on payment of fixed charges by the Government. At the time of pooling the produce in the form of *kalas*, the carts are inspected and purity of the produce is recorded on the basis of the degree of the boll opening and other distinguishing characters of the shell. The produce below 97 per cent. purity is rejected for certifying and agmarking.

The lint of the certified produce is pressed into full-pressed bales which are marked with the departmental agmarked labels, Red for nucleus and the First Stage and Black for the Second and Third Stage cotton. The agmarked produce is valued higher by about Rs. 10 than the uncertified. The seed, received after ginning the certified produce, is distributed for further sowing. A general idea of the multiplication rate can be had from the work done during the 1955-56 season as shown below :

Stage	Quantity of seed distributed (B. mds.)	Reserved area (acres)
Nucleus	10	45
First	355	1,900
Second	4,800	23,360
Third	22,800	1,00,600
Total	27,965	1,25,905

In Saurashtra and Kutch, work of seed multiplication and distribution on similar lines is being just organised with the improved variety Kalyan.

UTILIZATION OF COTTON SEED AND ITS PRODUCTS

The cotton seed is used mainly for sowing and feeding purposes.

COTTON LEGISLATION AND ZONES

The Cotton Transport Act of 1923 and the Bombay Cotton Control Act, 1942, are in force in Kalyan Cotton Zone comprising part of Ahmedabad, Mehsana and Banaskantha districts lying to the north-west of Sabarmati River. In Saurashtra and Kutch, these Acts are not yet in force. The Cotton Ginning and Pressing Factories Act, 1925, is in force in the tract.

KUMPTA COTTON TRACT OF BOMBAY-KARNATAK

The Bombay-Karnatak consists of three districts : Belgaum, Dharwar and Bijapur. It is noted for growing quality cottons. The tract can be divided climatically and commercially into two zones, viz.: (*i*) Kumpta-Dharwar area; and (*ii*) Dharwar-American area.

The Kumpta-Dharwar area mainly grows Kumpta (*G. herbaceum*) cotton. The area under cotton in the Bombay-Karnatak in pre-war years was about 15 lakh acres (11 lakhs under Kumpta cotton and four lakhs under Dharwar-American cotton). For the present (1954-55), the area under Kumpta-Jayadhar cotton is about 6,00,000 acres and that under Dharwar-American Laxmi cotton is about 5,00,000 acres. The annual production of Kumpta-Jayadhar cotton is about 1,00,000 bales. In recent years, after Laxmi cotton went into general cultivation in place of Dharwar-American Gadag No. 1, Laxmi cotton made inroards into the Kumpta-Jayadhar area. The Kumpta-Dharwar area can be divided into : (*i*) Dharwar Transition tract; and (*ii*) Eastern dry tract.

Dharwar Transition Tract. This consists of *talukas* of Bankapur, Haveri, Ranebennur, two-thirds of Dharwar and Hubli *talukas* and the whole of Bailhongal and one-third of Saundatti *talukas* of Belgaum district. The southern parts of South Satara district are also included in this zone.

Soils and Climate: This is the southern extremity of the great area of black cotton soil, derived from the Deccan trap. In fact, it is in this region that the Deccan trap disappears and the soils derived from it are partially or wholly replaced by those resulting from old sand stones and quartzite in Belgaum and Bijapur districts and from shales and schists in the Dharwar area proper. The soils are thus very variable. Where the soil is chiefly of a highly decomposed trap, it is usually very stiff and clayey; where it is entirely derived from other rocks, it is usually light in character. The Kumpta cotton tract has almost entirely deep black trap soils and medium black soils which consist of a mixture of trap soils with that derived from the other rocks. In other words, it has mostly stiffer kind of lands.

Climatic Conditions of Transition Tract: The average annual rainfall is about 30 inches in this tract, and is well distributed between May and November. The earlier rains permit of good preparatory tillage. Kumpta cotton is sown in August, i.e., after the soil is well saturated with moisture following good rains in July. The temperatures are not highly varying, the maximum not exceeding 104°F. and the minimum not falling below 45°F. Humidity is quite high during the sowing period of the crop, and the range during the other periods is quite agreeable to the successful growth of cotton. Besides, a common feature in this tract is winds. The growth of cotton depends on them, particularly after the cessation of rains. Westerly winds improve the crop, whereas easterly winds are harmful. The rainfall, temperature and humidity data for the Transition tract as recorded at Dharwar are given in Table 152.

TABLE 152. AVERAGE RAINFALL, TEMPERATURE (MAXIMUM AND MINIMUM) AND HUMIDITY RECORDED AT THE AGRICULTURAL RESEARCH STATION, DHARWAR

Month	Rainfall (inches)	Temperature (degrees F.)		Humidity, (per cent.)
		Maximum	Minimum	
April	0·736	97·5	69·8	59·8
May	3·742	95·3	71·8	70·07
June	3·416	84·6	70·0	79·8
July	7·284	81·1	69·7	85·5
August	2·626	79·3	68·9	85·0
September	3·578	84·3	66·2	79·9
October	5·122	84·9	67·1	69·16
November	2·276	86·5	54·7	56·4
December	0·288	84·0	58·2	55·2
January	0·064	85·7	55·7	52·7
February	0·034	90·4	63·9	64·0
March	0·462	97·8	68·2	63·3
Total	29·628			

Eastern Tract. This zone consists of the whole of Bijapur district, *Navalgund taluka* of Dharwar district and Athani *taluka* of Belgaum district.

Soils: The soils are usually stiff clay, tending towards loam and sandy loam on the river banks. Three big rivers, viz., Krishna, Ghataprabha and Malaprabha flow in the heart of the area.

Climatic Conditions: The climatological data on rainfall and temperature, etc., for the Eastern dry tract as represented by Bagalkot in Bijapur district are given in Tables 153a and 153b. A comparison of the data at Dharwar in the Transition tract and at Bagalkot in the Eastern dry tract shows that:(*i*) average rainfall is higher by about five inches in the Transition tract;(*ii*) while July is the month of heaviest rainfall in the Transition tract with

TABLE 153(a). YEARLY AND MONTHLY RAINFALL FOR 10 YEARS, FROM 1946 TO 1955, AT BAGALKOT

Year	Month												Total
	January	February	March	April	May	June	July	August	September	October	November	December	
1946	0·00	0·39	2·72	1·89	1·54	5·17	1·91	2·39	9·13	5·06	6·94	0·99	38·93
1947	0·44	0·09	1·11	1·05	1·48	3·17	4·77	4·25	1·38	3·13	0·43	0·02	21·32
1948	0·13	0·00	0·25	0·39	0·97	0·54	4·91	5·18	4·61	3·43	2·55	0·00	22·96
1949	0·00	0·00	0·00	0·79	1·12	2·04	3·75	2·37	11·98	4·46	0·22	0·00	26·73
1950	0·00	0·65	0·06	0·00	3·46	3·57	2·04	4·12	3·93	4·60	0·00	0·00	22·43
1951	0·00	0·00	0·00	1·57	2·60	2·83	3·54	1·29	4·81	8·52	0·00	0·00	25·16
1952	0·00	0·26	0·00	0·64	2·87	1·15	3·77	0·91	3·28	6·91	0·00	0·00	19·79
1953	0·00	0·00	0·00	0·71	0·00	2·35	7·54	1·00	5·83	9·91	0·00	0·00	27·34
1954	0·00	0·00	0·44	2·31	3·28	0·89	9·92	3·71	0·68	4·47	0·00	0·60	26·30
1955	0·00	0·00	0·12	1·72	3·34	4·05	4·28	2·80	0·56	5·32	0·35	0·00	28·54
Average	0·05	0·14	0·47	1·10	2·06	2·57	4·64	2·80	5·21	5·66	1·05	0·16	25·95

a second peak in October, in the Eastern tract, September is the heaviest rainfall month; (*iii*) the ante-monsoon rainfall (April-May) in the Eastern tract and *kharif* rains (June to August) are less by about three and eight inches, respectively, compared to those in the Transition tract. Frost does not occur in any of the tracts.

TABLE 153(b). AVERAGE MAXIMUM AND MINIMUM TEMPERATURE AND HUMIDITY, FROM JANUARY TO DECEMBER, AT BAGALKOT, FOR YEARS 1954 AND 1955

Month	Temperature (degrees F.)		Humidity (per cent.)
	Maximum	Minimum	
January	80·5	72·1	61·6
February	86·1	78·4	48·9
March	89·8	81·5	52·6
April	94·9	85·1	52·6
May	94·9	83·0	62·0
June	86·5	79·6	68·5
July	82·2	77·3	77·0
August	81·2	76·2	79·0
September	82·8	76·7	74·0
October	82·6	75·4	75·0
November	80·7	72·5	62·0
December	79·6	71·6	62·8

IMPROVED VARIETIES

As previously stated, with the establishment of the Agricultural Research Station at Dharwar, in 1904, cotton was the principal crop taken up for improvement. Experiments on the introduction of American cotton proving only partially successful, attention was concentrated on the improvement of Local Kumpta cotton. Detailed studies showed that what ordinarily passed as Kumpta variety was composed of several sub-types, differing in botanical, agricultural and economic characters. These differences were: either sympodial or monopodial growth-habit, the former conducive to earliness, and of variations in the yielding capacity, ginning outturn, fibre qualities and disease resistance, particularly the *Fusarium* wilt. As a result of straight selection from Local Kumpta cotton two pure lines, viz., Dharwar 1 and Dharwar 2 were isolated by 1913 (Kottur, 1920). Of these, Dharwar 1 was found to be an all round improvement over Local Kumpta. The average performance of Dharwar 1 against Local Kumpta gave an increase in yield by 10 per cent., in ginning outturn by three per cent. (28 *vs.* 25 per cent.) and in valuation by Rs. 20 more per candy of 784 lb. lint. The staple length of Dharwar 1 was 0.90 inches as against 0.82 inches of Local Kumpta and the spinning value 38's (H.S.W.C.) against 24's of Local Kumpta. The results of comparative performance of Dharwar 1 and Local Kumpta are given in Table 154.

TABLE 154. AVERAGE PERFORMANCE OF DHARWAR 1 AND LOCAL KUMPTA AT THE AGRICULTURAL RESEARCH STATION, DHARWAR

Strain	Yield of *kapas* (lb. per acre)	Ginning percentage	Fibre length (inch)	Spinning value (H.S.W.C.)
Local Kumpta	521	24·8	0·82	24's
Dharwar 1	563	28·5	0·90	38's

Dharwar 1 was released for general cultivation in the tract in 1918. In order to increase the ginning outturn of Dharwar 1 while retaining its earliness and good yielding capacity, it was crossed with Rosea, a *G. arboreum* variety. Two strains, viz., 15-9-9 and 1A-14-3, combining most of the good points of Dharwar 1 with 33 per cent. ginning outturn (a pretty high mark for Kumpta cotton) were isolated from this cross. Strain 15-9-9 popularly known as New Cross was grown on a large-scale in Haveri and Bailhongal *talukas.* It proved to be earlier than Dharwar 1 by about a fortnight. Its yielding capacity was as high as that of Dharwar 1. It had soft, white lint and had a high ginning outturn. This made the cultivators adopt it readily for cultivation without any propaganda. However, cotton wilt, which had made its debut in 1917, was spreading to large areas of the Kumpta cotton tract. By 1923, wilt disease had become a menace. The trouble was aggravated by the high susceptibility of Dharwar 1, New Cross and 1A-14-3 to wilt. Fortunately, another strain named Dharwar 2, a selection from Local Kumpta cotton was found to be highly resistant to wilt disease, though orginally selected for bushy growth habit and higher ginning outturn (27 per cent.) than ordinary Kumpta. A cross was, therefore, made between Dharwar 1 and Dharwar 2 in 1922 and a strain named Jayawant (meaning Victorious) was bred therefrom. In Jayawant are combined all the good agricultural and economic characters of Dharwar 1 and the wilt resistance of Dharwar 2 (Table 155). Jayawant was released for general cultivation in 1930 and soon covered the whole of the area of the Kumpta cotton tract.

TABLE 155. AVERAGE PERFORMANCE OF LOCAL KUMPTA AND JAYAWANT AT THE AGRICULTURAL RESEARCH STATION, DHARWAR

Strain	Yield of *kapas** (lb. per acre)	Ginning percentage	Fibre length (inch)	Spinning value (H.S.W.C.)
Kumpta	587	25·4	0·83	24's
(D.1 × D.2) Jayawant	703	28·5	0·93	40's

* Three years' average

From 1931 onwards, efforts were directed towards: (*i*) enhancing the ginning outturn of Jayawant; and (*ii*) the isolation of a homogeneous, 100 per cent. wilt-resistant strain, resistant even under the control conditions of a green house. The first object proved to be difficult of immediate achievement, as segregates from various crosses with Jayawant under study were found susceptible to wilt. The second objective was realised with the isolation of a strain named K.F.T. 12-2-5 in 1936 from Local Kumpta cotton. The K.F.T. 12-2-5 with its high productivity, earliness, 100 per cent. resistance to wilt and its fibre and spinning qualities similar to those of Jayawant, would have been an ideal substitute for Jayawant, had it not a low ginning outturn (24 to 25 per cent.). But it gave a very good base for further improvement, In order to breed a type with a higher ginning outturn than Jayawant, Strain K.F.T. 12-2-5 was crossed with the high ginning Segregate 1A-14-3 derived from Dharwar 1 × Rosea cross. By 1942, a synthetic strain 2-3-68 (later named Jayadhar) superior to Jayawant in yield, ginning outturn, and resistance to wilt disease, was isolated from this cross. Jayadhar was thoroughly tried with Jayawant for five years both on the Dharwar Farm and on cultivators' fields in the district (Table 156). The results show that Jayadhar gives an increase over Jayawant of *kapas* by 10 per cent., of lint by 32 per cent., and of ginning outturn by five per cent. (27 *vs.* 32 per cent.). The staple length of Jayadhar is 0.92 inches, against 0·86 inches of Jayawant and the spinning value 39's H.S.W.C. *vs.* 32's of Jayawant. On an average, the farmer gets about Rs. 20 more per acre by growing Jayadhar against Jayawant (Kelkar, Unpublished). Jayadhar was released for general cultivation in 1949 and it covered the whole of the Kumpta cotton tract within a period of five years. The general performance of Jayadhar in the Eastern dry tract could not come up to the expected level as in the Transition tract. A sub-station was, therefore, opened at Bagalkot in the Eastern tract, financed by the Indian Central Cotton Committee, to try the material available at Dharwar and subject it to selection, for the tract in question, right from the early stages. Further research work at Dharwar is directed towards getting types superior to Jayadhar in quality. Synthetic types from the crosses and backcrosses of long staple Surat type S.8 and K.F.T. are under trial.

TABLE 156. COMPARATIVE TRIALS OF JAYAWANT AND JAYADHAR

Item	Variety	Yield		Ginning Percentage	Staple length (inches)	Spinning value (H.S.W.C.)
		Kapas	Lint			
Mean of 13 comparisons on Govt. Farm, Dharwar	Jayawant	514	137	26·7	0·88	32
	Jayadhar	581	186	32·1	0·94	41
Mean of 21 controlled village trials	Jayawant	346	94	27·1	0·85	31
	Jayadhar	389	127	32·3	0·91	35
Mean of 31 village trials	Jayawant	349	95	27·4	0·86	—
	Jayadhar	365	119	32·3	0·90	—
Mean for the whole tract and five seasons	Jayawant	403	109	27·1	0·86	31
	Jayadhar	445	144	32·2	0·92	38

COTTON CULTIVATION

Preparatory tillage for cotton starts with the advent of ante-monsoon rains. It consists of one ploughing and two to three harrowings, to crush the clods and to remove the stubbles. Sometimes stubbles are collected and burnt but more often they are not removed. The sowing is usually done during the second fortnight of August in the Transition tract and during September-October in the Eastern tract. Seeds are plastered with cowdung with a view to separating them and to facilitate easy and regular dropping through the drill at the time of sowing. The seed rate is 8 to 10 lb. per acre. The spacing between the rows is 18 to 24 inches (18 inches being more common in the Eastern tract) while spacing in between the plants is not regulated. Generally, cotton is grown as an entire crop. But sometimes, it is grown with a sprinkling of *kulthi* and *ambadi*, particularly in the Eastern tract. In the Transition tract, in certain areas, cotton and groundnut are sown in separate rows in the same field. Cotton followed by *jowar* is the common rotation. A three-course rotation of cotton-*jowar*-groundnut is also in vogue. Another three-course rotation, *jowar*-cotton-wheat is also common, especially in the Eastern tract. Cotton is not manured directly but the previous crop of *jowar* receives about five cart loads of farm yard manure per acre. As rainfall is very erratic in the Eastern tract, even *jowar* crop is not regularly manured. The after-tillage process consists of four to five interculturings given as and when necessary and one or two hand-weedings. Soil moisture is the chief limiting factor for the satisfactory growth of cotton. The plants grow to a height of two to four feet; better growth is observed in the Transition tract. The crop begins flowering by the end of November in the Transition tract and end of December in the Eastern tract. It is ready for harvest in the second fortnight of February in the Transition tract and in the middle of March in the Eastern tract.

PESTS AND DISEASES

Pests. The pests of major importance for *herbaceum* cotton are: Spotted Bollworm and Pink Bollworm. Those of minor importance, their incidence varying with climatic conditions, are : Cutworms or surface caterpillars on young seedlings which can be controlled by five per cent. BHC dustings; Aphis on leaves; Red Cotton Bug; Dusky Cotton Bug; and Wooly Mite. Jassids and Thrips are generally the pests of American cotton.

Diseases. The most common disease of cotton is cotton wilt. It is, however, successfully controlled by breeding wilt-resistant types. Other diseases of minor importance are Root Rot of young seedlings in the Eastern tract; Grey Mildew affecting the leaves; and Blackarm which attacks the various parts of the plant body, in American cotton.

HARVESTING AND YIELD

The harvesting of Kumpta cotton usually starts in the first week of March and by the middle of April three to four pickings are taken. The picking is generally done in the morning specially so in the Eastern tract as the weather is comparatively hot. Further, morning picking ensures a cleaner produce, as the cotton leaf pieces are somewhat damp and do not break and stick to *kapas*. In the Transition tract, the pickings may extend up to 4 p.m., the weather being cooler there. Late season pickings are usually caught in rains, which come regularly in the last week of April. The pickings are generally done on a contract basis, the present prevailing rate being 75 nP. per maund (28 lb.) of *kapas* havested. The yields in the Transition tract may go as high as 500 lb. *kapas* per acre, whereas the average yield for the tract is about 250 to 300 lb. *kapas* per acre, giving about 70 lb. lint. In the Eastern tract, the yield of *kapas* does not generally exceed 200 lb. per acre.

MARKETING AND GINNING

Marketing. As soon as picking is over, *kapas* is collected and stored generally in rooms in the cultivators' premises. Big landlords have separate godowns for the purpose. During the marketing season, the produce is filled in *bardans* (big, thin, gunny sacks), commonly known as *dokras* and brought to the nearest marketing centre, either directly by the growers or by the local traders, who buy it from the growers. The movement of cotton generally starts from March and continues till August every year.

Cotton growers, on whose lands the Reserved Areas of various stages are organised by the Agricultural Department bring their seed cotton in *dokras* (bundles of 300 to 400 lb.) to the premises of the approved agents, co-operatives or private agents, as the case may be. Here the staff appointed by the Argicultural Department, first verify that the produce is from particular stages of multiplication in the Reserved Area and they grade it into three grades on the basis of ginning percentage, approximate staple length, colour and cleanliness. Cotton not meeting the requisite standards is rejected. *Dokras*, pooled gradewise are then auctioned to merchants on the condition that they agree to get the cotton of various stages ginned and pressed under the supervision of the staff of the Agricultural Department and to sell the resultant seed unmixed to the Department. Certificates of different grades are issued for the resultant full-pressed bales. Cotton from the General Area is also graded under the supervision of the Agricultural Department by market committees established under the Agricultural Produce Market Act, wherever they exist.

The unit of price quotation of *kapas* is one *nag* of 48 maunds (1344 lb.) in Dharwar district and one *akki* of eight maunds in Bijapur and Belgaum districts and that for lint is 12 maunds (336 lb.).

Marketing facilities in general are good. The important markets in Karnatak for Kumpta cotton are at Dharwar, Hubli, Kundgol, Nargund, Savanur in Dharwar district; Bailhongal, Mudhol, Jamkhandi, Athani and Kagwad in Belgaum district, and Bagalkot and Bijapur in Bijapur district, All these markets are regulated markets. As soon as the *kapas* arrives in the market, it is graded by the departmental staff and the value is fixed, usually by auction sales.

Ginning and Pressing. In most of the *talukas*, the rate for ginning is fixed per *nag* of lint, weighing 12 maunds (336 lb.), the present prevailing rate being Rs. 12. In some localities, where there is a superfluity of gins, they work in pools and distribute the profit among themselves. Ginning starts from March and ends in July. There are enough presses in the cotton growing tract, though each cotton centre may not have a press. Here also, the presses work in a pool and distribute the profit among themselves. Pressing starts in April and extends even up to September. Communications between big markets in Karnatak and Bombay are usually by rail. Interior markets like those at Ron and Mudhol are connected to highways and are situated near railways.

ECONOMICS OF COTTON PRODUCTION

Cotton is the money crop of Karnatak and the cost of cultivation of Kumpta cotton works out as follows (Table 157).

TABLE 157. COST OF CULTIVATION OF KUMPTA COTTON

Item of cultivation	Labour units			Cost per acre
	Men	Women	Bullocks	
Total Cost:				Rs.
Ploughing	2	—	4	8·00
Harrowing (four times)	2	—	4	8·00
Manuring:				
Cotton not manured but 50 per cent. of the cost of manure to jowar—2½ cart loads	—	—	—	10·00
Sowing and covering	1	1½	2	4·94
Interculturings (four times)	2	—	2	5·00
Weeding (thrice)	—	12	—	7·50
Harvesting (250 lb. *kapas*) by contract at 75 nP. per md. of 28 lb.				6·75
Cost of 10 lb. seed at Rs. 5 per md. of 40 lb.				1·25
Land assessment				5·00
Interest on outlay				5·00
			Total	61·44
Total Receipts:				
250 lb. *kapas* at Rs. 525 per *nag* of 1344 lb.				96·75
Net Profit: Rs. 96·75 *minus* Rs. 61·44 = Rs. 35·31				

Note:—One man with a pair of bullock costs Rs. 4 a day and one woman at 62 nP. per day.

With the present prevailing prices of Kumpta-Jayadhar cotton the net realisation after deducting the cost of cultivation is about Rs. 35 per acre.

SEED MULTIPLICATION AND DISTRIBUTION

Multiplication and distribution of pure seed of improved varieties is carried out on a systematic basis. Seed reaches the hands of the cultivator in six stages. The first two stages are under the control of the cotton breeder. In the First Stage, seed is raised from the pure selfed seed and is again rogued, selfed and ginned under supervision to maintain purity. The Second Stage is either on the Government Farm at Dharwar or on farms under departmental control owned by registered seed growers. For Jayadhar cotton the Second Stage seed is grown on the Dharwar Farm, Dharwar, and the Dhannur Farm in Bijapur district. The resultant seed obtained from the produce of the Second Stage, i.e., the seed for the Third Stage is supplied by the Cotton Breeder, Dharwar, to the Cotton Superintendent, Dharwar, for being multiplied at nine centres in the tract. The seed of the Third, Fourth and Fifth Stages, which is multiplied with the help of registered seed growers, is purchased, stocked and distributed stage-wise with the help of the approved agents. The entire work is carried out under the close supervision and guidance of the special cotton staff. The produce of the Third, Fourth and Fifth Stages is pooled in the premises of the approved agents by registered seed growers and it is graded as referred to earlier by the departmental cotton staff and sold by public auction to enable the growers to receive adequate premium over the ungraded lots sold in the market. The system of grading of *kapas* of improved cottons has become very popular amongst the trade interests and the growers, as the former are in a better position to buy pure and high grade cotton in bulk and the latter to receive a higher price for their produce. The premium obtained for such graded cotton is about Rs. 25 per *nag* of 1344 lb. *kapas* over the ordinary lot.

Maintenance of Purity of Improved Strains. The purity of the improved varieties, in all the stages, is maintained by adopting the following measures.

1. Reserved Area of the Third, Fourth and Fifth Stages of Jayadhar cotton is organised in compact blocks in the fields of registered seed growers at all the nine seed multiplication centres operating in this division.
2. The area is rogued or inspected for purity.
3. The seed cotton is graded, ginned, pressed and purity certificates issued under the close supervision of the special cotton staff. In this way, nearly 45,00,000 lb. of seed of improved cotton Jayadhar is at present being handled for the Reserved Area of about 4,00,000 acres.

UTILIZATION OF COTTON SEED AND ITS PRODUCTS

Whole cotton seed is at present being used mainly as cattle feed. Part of the seed is used for sowing. The cotton seed crushing industry has, as yet, not very well developed, although a move in that direction is being made.

COTTON LEGISLATION AND ZONES

The following Acts are in operation in the Kumpta cotton tract of the Bombay-Karnatak:

1. **Cotton Transport Act.** Under this act, the Bombay-Karnatak tract is divided into three zones:
   - (i) Kumpta-Dharwar Protected Area, comprising Dharwar, Belgaum, Kolhapur and South Satara districts.
   - (ii) Bagalkot Protected Area, comprising Bagalkot, Hungund and Badami *talukas* and Bilgi Petha of Bijapur district.
   - (iii) Bijapur Protected Area, comprising Bijapur, Indi, Sindgi, Bagewadi and Muddebihal *talukas* of Bijapur district.

The movement of cotton, cotton seed or *kapas* from one protected area into another and also from outside areas into any of these protected areas is prohibited under the provisions of this Act. Besides, to check the illicit import of cotton seed, *kapas* or lint from non-protected areas and from one protected area into another, nine permanent cotton check stations have been established along the boundry line of each of these three protected areas at the strategic points. In addition, 41 cotton check stations are also temporarily established during the cotton season, i.e., from February to July, every year and each cotton check station is in charge of a Nakadar.

2. **Cotton Control Act, 1942.** Under this Act, cultivation or possession of and dealing in any variety of cotton other than those approved by the Agricultural Department is strictly prohibited. Mixing of two or more standard varieties of cotton is also prohibited.
3. **Cotton Ginning and Pressing Factories Act, 1925.**
4. **Cotton Statistics Act, 1946.**

GROWING OF LONG STAPLE INDO-AMERICAN VARIETIES

These varieties have been recently taken up for cultivation in Gujerat, Saurashtra and Kutch, and in the Bombay-Karnatak (which includes the western *herbaceum* tracts dealt with here) and also in the *arboreum* regions of Khandesh and the Deccan, particularly where irrigation facilities are available. They are bred from the crosses and backcrosses of (American × Indian) × American cottons. As is well-known, the first generation hybrids of American × Indian cottons are self-sterile. However, fertility can be induced by backcrossing the sterile hybrids to American cottons. Accordingly, 170-Co.2 is derived from the Fertile Backcross 170, further crossed to Madras Cambodia variety Co.2 (*G. hirsutum*). Fertile B. C. 170 itself was obtained from Dharwar-American 2-6-5 (*G. hirsutum*) × Gaorani 6 (*G. arboreum*) F_1 which was self-sterile but was open pollinated possibly by an American cotton variety. Similarly 134-Co.2-M is derived from the crosses of Fertile B. C. 134 crossed to Co.2 (*G. hirsutum*), further crossed to Meade (*G. hirsutum*). Fertile B. C. 134 itself was obtained from the cross of D.A. 2-6-5 × 1027 A L. F. (*G. hirsutum* × *G. herbaceum*) F_1 self-sterile back-crossed to D.A. 2-6-5 (*G. hirsutum*). The hybrid material of the above origin was worked in detail as a part of the research work in the Scheme for Interspecific Hybridisation in Cottons at Surat, which was financed by the Indian Central Cotton Committee (Thakar, and Amin, 1936; Amin, 1940;. Patel, and Thakar, 1950 ; Patel, and Patel, 1954; Bhat, and Patel, 1955). The varieties, 170-Co.2 (named Deviraj) and 134-Co.2-M (named Devitej), the term Devi suggesting that the variety originated from crosses between *desi* and *vilayati* cottons, are released for cultivation particularly where irrigation facilities are available, keeping also in view the prospective development of canal irrigation in the country. 170-Co.2 has the staple length of 1″ to 1-1/16″ and 134-Co.2-M, 1-1/8″. These cottons are attacked by pests like thrips, jassids and aphis and by blackarm disease. Remedial measures against these pests and diseases are being adopted. The total area under these cottons is about 2,50,000 acres. Seed multiplication and distribution plans for these two varieties are being organised from the latest selected plant material. Their cultivation interspersed as it is in *herbaceum* or *arboreum* regions requires special, careful handling of the produce (the quality of which varies according to varied growth conditions) for ginning and marketing it in a pure form. This work is also on hand. It is hoped that ultimately it will be possible to produce at least a part of the 6,00,000 bales of long staple cotton, at present imported into the country.

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CHAPTER VI

EASTERN REGION

INTRODUCTION

The Eastern Region, comprising the States of Orissa, Bengal, Bihar, Assam, Manipur and Tripura, lies between 22° and 28° N. latitude and between 86° and 97° E. longitude, covering roughly an area of 2.5 lakh square miles. It is bounded by the Himalayas on the north, Burma on the east, the Bay of Bengal on the south and the States of Uttar Pradesh and Madhya Pradesh on the west.

Although the entire zone is vast in extent, the total cotton production is negligible. The annual area of cotton grown in Bengal and Bihar is very small, as cotton is cultivated in isolated patches or as perennial bushes in the compounds of temples and *maths*. The entire cotton production in Orissa is consumed locally for extra-factory needs, and as such there are no trade varieties. Among the various varieties cultivated in that State, Achnar and Haldia—two old varieties of cotton—have gone out of cultivation; Podupathi, the possible perennial progenitor of southern *indicum* is grown in agency tracts ; a local monopodial variety called Patsalia (*Pat* means cloth and *Salia* signifies weaver) is found in the sub-mountainous portions of the Eastern Ghats ; Turturi, an indigenous cotton constitutes the general crop of the central and western districts and is made up of khaki and white-linted types having very short staple ; and small-bolled Cambodia and Kidney cotton plants are found in house and temple compounds as perennial bushes. Comillas, the only cotton of commercial importance is cultivated in the hilly areas of Assam, Manipur and Tripura States where the hill ranges vary in height from 1,000 to 6,000 feet above the sea level. These States are considered to be important centres of variability where from the races *cernuum*, *sinense*, and *bengalense* are supposed to have been derived from *G. arboreum* race *burmanicum*. The major component of cotton grown on the Garo Hills is race *cernuum* ; on the Tripura Hills, it is mainly race *bengalensis* ; on the Manipur Hills the race is *sinense* ; and on the Lushai Hills bordering Burma, the races *bengalense* and *burmanicum* (similar to Waggi and Wagale of Burma) are found.

Cottons found in Assam, Manipur and Tripura zone differ very little in their morphological and general features. Minor differences exist in leaf, flower, boll, colour and other characteristics. The extent of these variations is related to the botanical composition of the crop, which may differ from hill to hill. Table 158 furnishes the ranges of values for various places of growth.

TABLE 158. VARIETAL CHARACTERISTICS OF RACES GROWN IN THE EASTERN REGION

Characters	*Cernuum*	*Bengalense*	*Sinense*	*Burmanicum*	
	Garo Hill	Naga Hill	Tripura Hill	Manipur Hill	Lushai Hill
Bracteole length (mm.)	50-60	40-50	35-45	50	35-45
Petal length (mm.)	40-48	35-45	25-50	40	25-25
Boll length (mm.)	60	50	40	25-30	35
Number of seeds in a boll of three locules	45-54	36-40	27-39	15-21	24-39
Weight per seed (mg.)	60-90	50-70	50-60	—	—
Ginning percentage	42-52	40-44	30-45	28-30	26-46
Halo length (mm.)	10-16	12-16	12-16	18-22	12-16
Highest standard warp count	6-8	6-8	6-8	—	6-8

The fine and medium staple lint found around Manipur and Abor Hills and the capacity of Patsan to adopt itself to high altitudes (above 1,500 feet over mean sea level) are some of the special features of some of the cotton varieties grown in the zone.

The Comilla cotton is mainly prized for its coarseness and low wax content. The fibre weight ranges from 0.379 to 0.399 millionth of an ounce per inch, while the wax percentage is as low as 0.21. Harsh feel, high resilence and freedom from the tendency to get matted are the special virtues of this variety valued in markets. The variety is largely used in manufacturing upholstery, carpets and high grade absorbent cotton, and for mixing with wool.

The average annual area and production for various States in the region are furnished in Table 159 (Figs. 34 and 35).

TABLE 159. AREA AND PRODUCTION OF COTTON IN THE EASTERN REGION

State	Area (acres)	Production (bales of 392 lb. lint)
Orissa	20,000	3,000
Bihar	13,000	3,000
Bengal	12,000	3,000
Assam	35,000	12,000
Tripura	23,000	8,000
Total	1,03,000	29,000

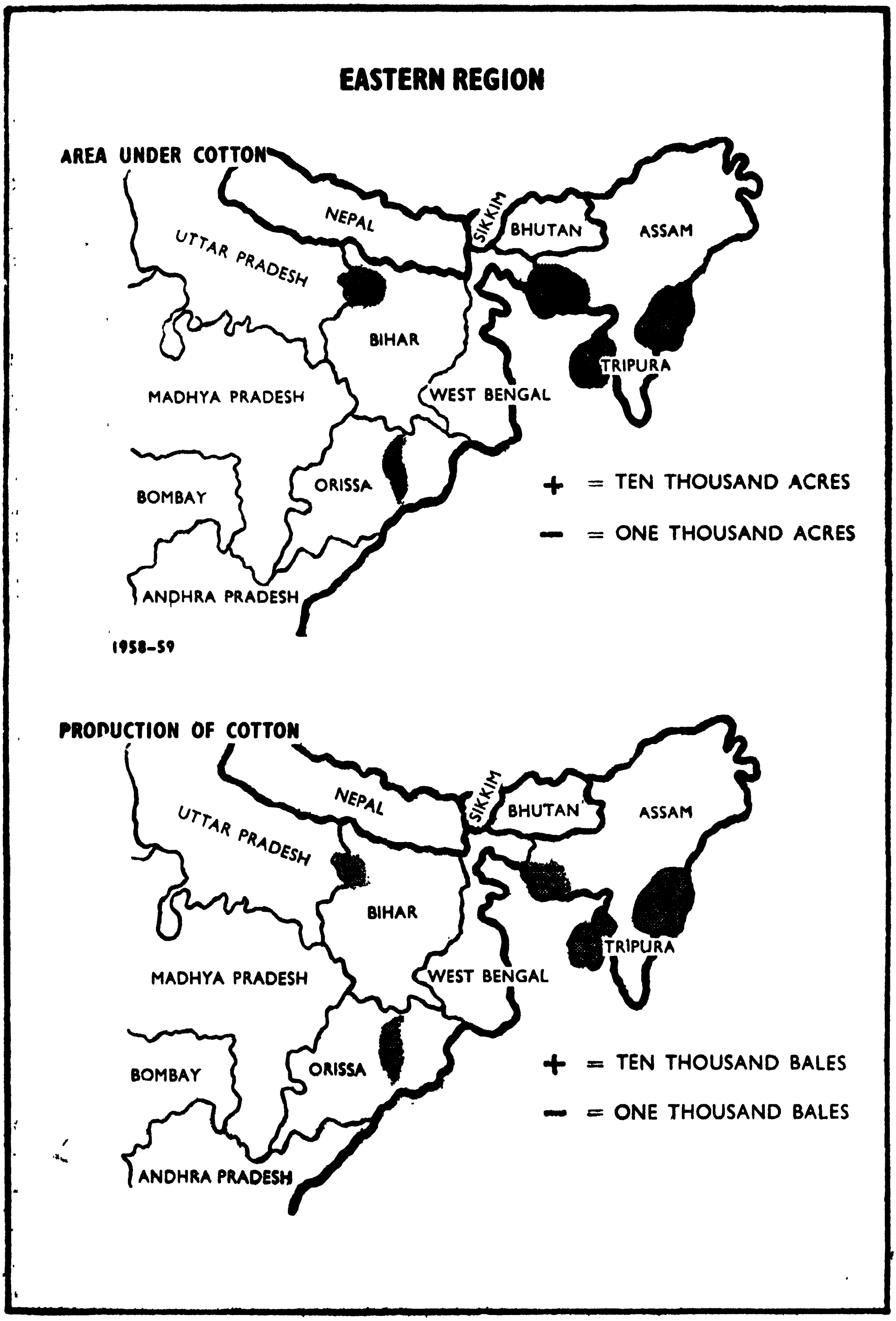


Fig. 34. Intensity of Area and Production of Cotton in the Eastern Region

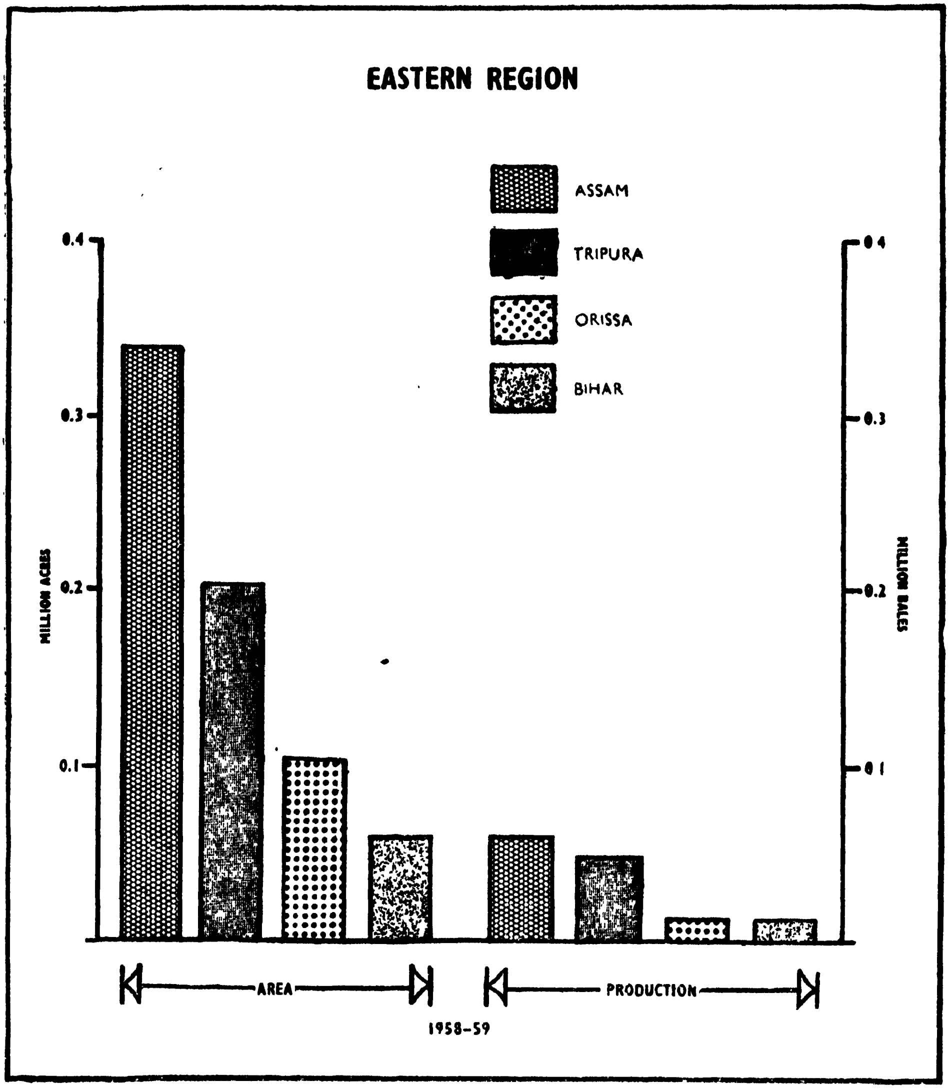


Fig. 35. Area and Production of Cotton in Different States of the Eastern Region—1958-59

The pre-War production of Comillas and other cottons in Assam region was approximately 55,000 bales. This estimate may have been on the low side due to the large local demand for extra-factory consumption and surreptitious movement across the border to Pakistan.

The progress in the area and production of cotton during the First and Second Five-Year Plan periods (up to 1958-59) are depicted in Figure 36.

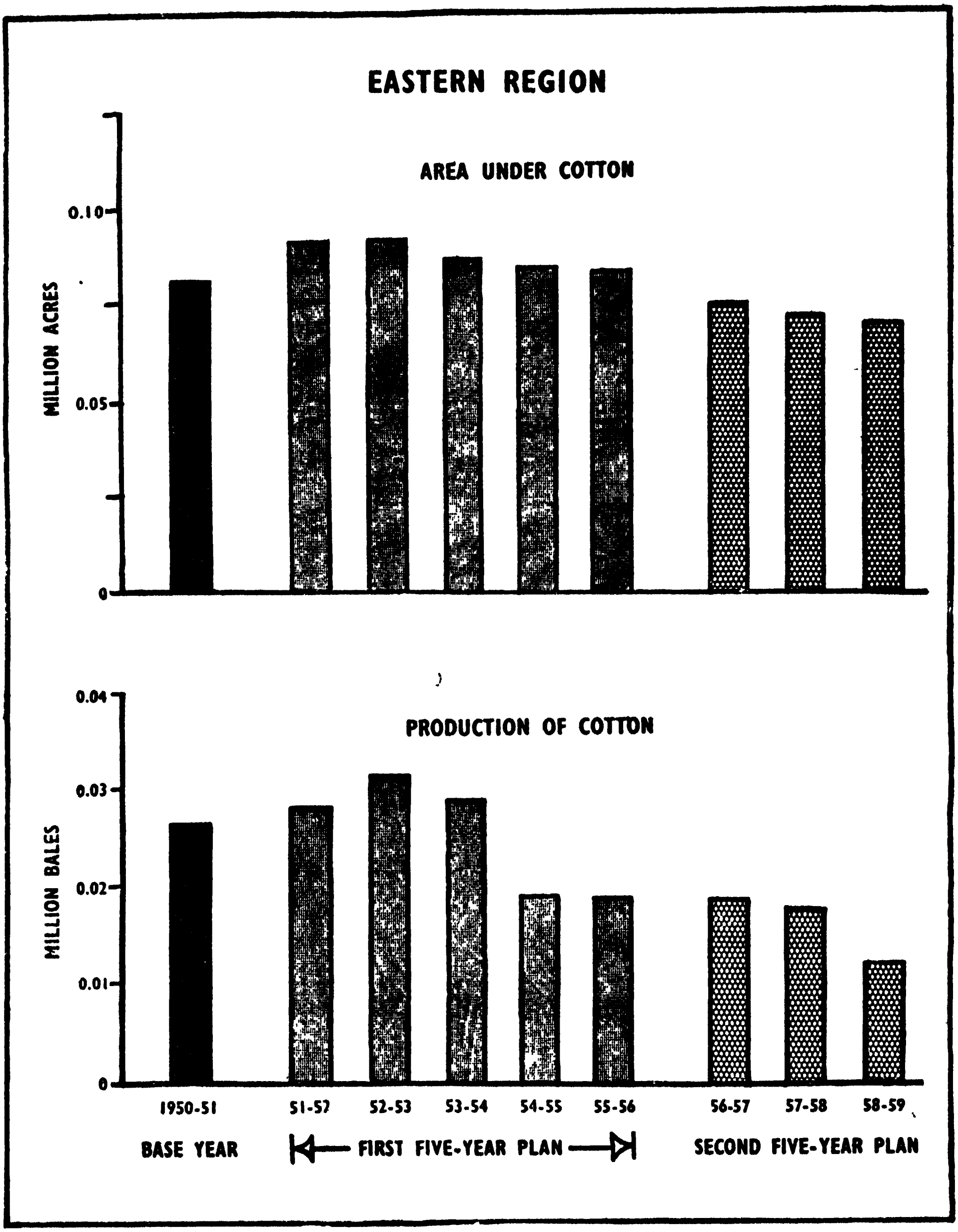


Fig. 36. Area and Production of Cotton During the First and Second Five-Year Plan Periods

SOILS AND CLIMATE

Assam, Manipur and Tripura are full of valleys and hills of varying elevation. The valleys are fertile as they are enriched by the deposition of silt washed down the hill slopes by heavy rainfall. The hillsides are mostly sandy and covered by thick forests. Cotton is largely grown on such well drained porous soils, where hill folk establish settlements and clear the jungle for cultivation. A major portion of Bihar and Bengal States has either a high water table or is low-lying. Parts of central and western districts can grow cotton. In Orissa the western districts and central table land may be stated to be potential cotton areas. The rest of the State is mountainous and forest clad or deltaic, fit for paddy cultivation.

The important characteristics of the newly-reclaimed Assam soils are their high organic content (10.4%), rich nitrogen (0.22%), low pH value (5.2 to 5.6), and sandy texture (80.8% acid insoluble residue). Loamy soils (0.50 N and 6.4 pH) in western Bengal are the areas fairly suited for cotton cultivation. In a large portion of central Bihar, the water table is high and as such, only the southern part of the State, where the land dries up with the cessation of the monsoon, will be able to grow cotton. The cotton soils of Orissa vary from alluvium to sands. The composition of the central Orissa soils is given in Table 160.

TABLE 160. COMPOSITION OF SOILS OF CENTRAL ORISSA

Type of land	Nitrogen % (N)	Potash % (K_2O)	Phosphoric acid % (P_2O_5)	Sand %
High	0·308	0·292	0·065	80·95
Medium	0·588	0·342	0·027	69·85
Low	0·700	0·325	0·031	70·90

Assam has the rainfall characteristic of the coastal region like Kerala State. Pre-monsoon rains received in April are often attendant with high winds and lightning. Sharp showers in May, followed by torrential rains (from June to September) which again trail off in October, is a fair picture of the monsoon in Assam and the neighbouring hills. The total quantity of rainfall in any particular area, however, varies on account of the differences in the physical features of the region. The Khasi and Jaintia Hills sprawling towards the west impede the monsoon-bearing clouds and induce them to precipitate a very high rainfall of about 500 inches around Cherapunji, while the hills themselves receive 230 inches of rain in a year. Other hilly regions in Assam, Manipur and Tripura record 100 to 125 inches, while in the valleys, the rainfall range is between 60 to 75 inches per annum.

Bihar is a typical inland tract ; very hot in summer and cold in winter. The northern portion receives more rain than the plains in the middle Bihar. In general, the rainy season commences by the end of June and ends by mid October. The average annual rainfall of the State ranges from 35-60 inches.

The climate of Bengal is hot and humid throughout the year. The western part is, however, comparatively dry, with a maximum temperature of 105°F. and a minimum of 50° F. The annual precipitation in the western portion is about 55 inches.

Orissa has three well-differentiated seasons : (*i*) moderately warm, wet season from June to October ; (*ii*) cool, dry weather from mid-October to February; and (*iii*) hot, dry season from March to May. The coastal part records an average annual rainfall of about 60 inches, of which nearly 48 inches fall between June and September. Cyclonic storms are fairly common in the northern and upper portions of the coastal belt. The western districts of Orissa, served by the canals from the Hirakud Dam, receive a lower rainfall of about 42 inches, with high intensity during September.

Table 161 furnishes the general rain pattern of the important cotton-growing zones in the various States (Fig. 37).

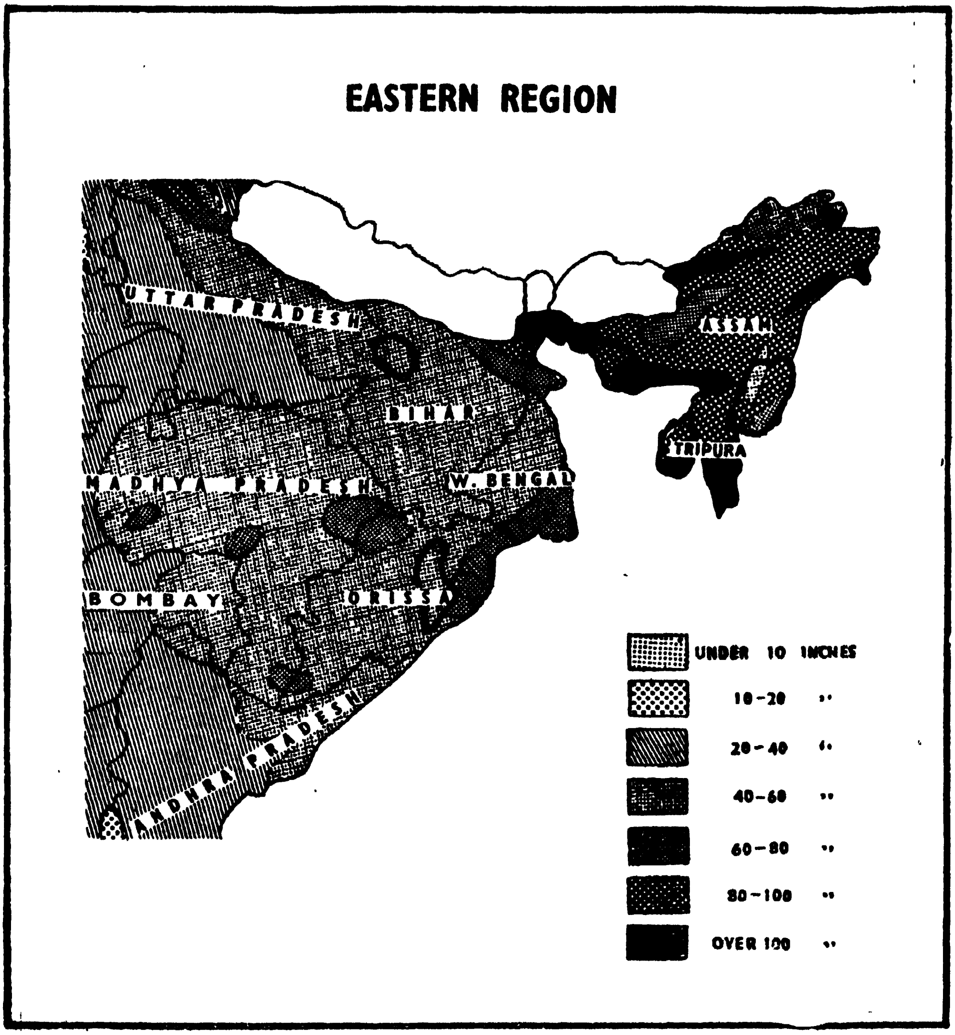


Fig. 37. Rainfall Pattern of the Eastern Region

TABLE 161. RAINFALL PATTERN OF IMPORTANT COTTON GROWING ZONES IN THE EASTERN REGION

Name of State and Zone	Rainfall (inches)												
	January	February	March	April	May	June	July	August	September	October	November	December	Total
Assam													
Tura	0·13	1·08	1·02	10·20	20·40	34·50	19·10	27·30	19·30	15·90	1·80	0·01	150·74
Kohima	—	—	4·20	6·90	12·60	11·00	18·50	16·80	13·30	5·90	1·50	—	86·70
Bengal													
Western portion	—	—	—	1·70	4·70	10·20	12·70	12·80	8·50	3·80	0·90	—	54·60
Orissa													
Western districts	—	—	—	—	—	7·94	6·31	8·42	19·25	0·71	—	—	42·63

TABLE 162. MAXIMUM AND MINIMUM TEMPERATURE

Place	Temperature (degree F.)											
	January	February	March	April	May	June	July	August	September	October	November	December
Garo Hill												
Maximum	78	77	85	88	87	85	86	84	87	87	82	77
Minimum	58	58	70	73	74	76	77	77	77	73	64	58
Sambalpur												
Maximum	84	89	94	103	103	104	109	86	88	88	84	83
Minimum	52	59	65	75	81	81	78	77	76	70	59	54

Humidity is very high in Assam, the lowest figure of 76 per cent. being recorded during the hot months of March and April. The percentage is 80 to 90 during the harvest months of October to December. Moist tropical weather and low minimum temperature associated with higher latitudes are a climatic combination peculiar to Assam and the neighbouring hilly regions. The biggest difference between the maximum and minimum temperatures in any month is not more than 20 degrees. The States of Bihar, Bengal and Orissa, on the other hand, are comparatively less humid and considerably dry during the months preceding and succeeding the monsoon. The mean monthly maximum and minimum temperatures recorded in Garo Hill (Assam) and Sambalpur (Orissa) are given in Table 162.

IMPROVED VARIETIES

The States comprising the Eastern Region have no outstanding improved variety under general cultivation since both the annual acreage and the commercial importance of the cottons grown in them are small. A survey of the hill areas of Assam and Chittagong was undertaken when the State of Bengal was undivided. After partition in 1947, steps for the improvement of Comilla cotton were taken with a view to evolving high-yielding strains of coarse short staple cotton with high ginning percentage and capable of finding a large export market in foreign countries. The work is still in the experimental stage. Among the various varieties evolved and undergoing tests, D. 46-2-1 was the best, with a ginning outturn of 1.8 per cent. over the local bulk (45.7%). In addition to research on improvement of Comilla cotton, exploratory trials with the 'Andrews' variety of Sea Island cotton are also undertaken in Assam, Manipur and Tripura States, where the climatic conditions are similar to those in Kerala State.

Research in Orissa State is still in its infancy. The main objects are : (*i*) to develop improved varieties of American cotton with mean staple length of one inch and capable of spinning 40's H.S.C., (*ii*) to evolve suitable *arboreum* strains possessing 13/16″ staple and 33 per cent. ginning ; and (*iii*) to survey the cotton areas of Sambalpur and Sundergarh districts prior to the commencement of full-scale breeding work. The main centres of work for the first two items are Chaukudi and Arkalnhali. The trends are in favour of M.C.U. 1 under irrigation and P. 216F as unirrigated crop during *kharif* season.

The varietal trials now conducted in the States of West Bengal and Bihar are focussed on the possibility of growing long staple cotton in the highland areas. They are recent and in the exploratory stage.

COTTON CULTIVATION

SEASON

The months of planting, being directly related to the differing rainfall incidence, soil categories and facilities for irrigation, vary a great deal. In

Assam, cotton is normally planted by the end of April; in Orissa the *kharif* crop is sown in June and *rabi* cotton (irrigated) is dibbled in September-October ; and in Bengal and Bihar States, the planting months are May-June.

ROTATIONS

In Assam, Manipur and Tripura States, a method of shifting cultivation known as *jhum* or *tungya* is largely in vogue. Hence there is no rotation. Mixed cropping is the rule. Crops like paddy and *bhendi* (*Hibiscus esculentus*) are sown mixed with cotton. In some places, cotton is sown broadcast after paddy. In areas where the *jhum* cultivation is combined for a second year also, other crops like *til*, chillies, gourds and sweet potato are usually planted after cotton.

In Bengal and Bihar States, where cotton occupies a very minor place, there are no definite rotational practices. Three types of rotations, viz. : (*i*) paddy-legume-cotton in one year; (*ii*) paddy-cotton in first year and paddy-legume in the second year in a two-course rotation; and (*iii*) monsoon cotton in the first year and paddy-lugume in the second year are under trial in the Chaukudi Farm in Orissa State.

PREPARATION OF LAND

In Assam, Manipur and Tripura, the valleys are regularly cultivated. The hill slopes are cultivated for a year or two and then abandoned for a period which may extend to about 10 years. This method of shifting cultivation is called *jhum* or *tungya*. The selected site will have at least a five-year jungle growth, preferably bamboo. By the end of March, the bamboos and shrubs are cut and cleared. A hut is built in the cleared area of three to five acres. The loppings and trash are allowed to dry and then set fire to. The ash gets incorporated in the hollows of the land during the rains in April. The soil being sandy in texture and high in fertility, the roots of crops have no difficulty in establishing themselves and in putting on rapid growth. In recent years, terrace cultivation has been introduced. The terrace is of the narrow bench type. The land is harrowed two or three times in March-April before scattering the seeds of crops soon after the rains come.

Harrowing the land during the summer months is a general practice for all lands intended for cotton in the States of Bengal, Bihar and Orissa. In parts of Orissa, where the rains are heavy and where cotton is sown as a *kharif* crop, the land is thrown into ridges and furrows and the cotton seeds are planted on the ridges. The harrowing operation for *rabi* sowings in the State is done during September-October.

METHOD OF SOWING

In the hilly areas of Assam, holes are made in the uncultivated soil with a pointed stick or a long knife called *dao* and about 20 lb. of cotton seed mixed with other seeds like paddy and *bhendi* are dibbled in one acre. In recent years, terrace cultivation is being recommended and in such lands the cotton crop, when sown unmixed with other crops, is sown broadcast. Planting on ridges for the rainfed *kharif* and the irrigated *rabi* cotton is the normal practice in Orissa.

SEED RATE

In Assam and the neighbouring hilly areas, the sandy texture, humid hot climate and roasted soil, encourage rapid growth of cotton seedlings but when paddy is sown mixed with it, the cotton crop is partially smothered and suffers from lack of sunshine. A high seed rate of about 25 lb. per acre is, therefore, adopted for *jhum* cultivation, while for the terrace-cultivated lands a lesser quantity of 15 lb. per acre is sown broadcast for a pure cotton crop. In the combined spacing-*cum*-seed rate trials, no differences in yield were noticed among 9, 12 and 15 inch spacing, or one, two and three seeds per hole.

MANURE

No manure is usually applied to *jhum* cotton in Assam. Application of ammonium sulphate has been noted to produce excessive vegetative growth and to lead to loss of crop during the period of water stress in October. On terraces, however, 20 lb. N as ammonium sulphate and three maunds of bone meal per acre, applied as a basal dressing of five to ten cart-loads of cattle-dung, have yielded good crops. Five cart-loads of cattle-dung followed with a top dressing of 20 to 30 lb. N in the form of nitrogenous fertilisers are usually recommended for rainfed cotton. Higher dosage is found necessary for the irrigated crop.

AFTER CULTIVATION

Thinning of cotton seedlings is done in Assam when the germination is in bunches and where the seedlings are very close.

Two weedings are given during the seedling stage. No inter-cultivation is possible in *jhum* crop and the fast-growing paddy keeps down the weed growth. The monsoon crop in Orissa is weeded four times, while the *rabi* crop receives only two weedings. Inter-cultivation in the rainfed crop is done by working the plough along and across the rows so as to leave the cotton plants on mounds. Occasionally, the stagnant water is drained by manual labour during heavy rains.

DISEASES AND PESTS

In the heavy rainfall zones, anthracnose, *Pythium*, and *Macrophoma* are the common fungal diseases attacking cotton. The American cotton in Bengal and Orissa suffers from blackarm disease. The incidence is, however, restricted to the monsoon crop in Orissa, the cold weather crop being free.

Bollworms attack the hill cottons and cause considerable damage. Other minor pests are leaf rollers and jassids, found on American cotton.

HARVESTING AND YIELD

The harvests commence by the middle of October in all monsoon-sown cottons. It is over by the end of December in the hilly areas of Assam zone while it continues up to March in Orissa and Bengal. The *rabi* cotton comes to havest during February.

A cotton crop grown on hill slope is shown in Plate XVII, while Plate XVIII gives a closer view of the crop.

The cotton is gathered by human labour and stored in a dry place. The *jhum* cotton is stored on raised bamboo platforms erected near the residential huts.

The yield of seed cotton per acre varies with the type of cultivation, the incidence of rainfall and the nature of hill slopes in Assam State. The average yield of a *jhum* cotton is about 280 lb. per acre (equivalent to 112 lb. lint). The yield levels on terrace cultivated cotton are stated to be lower than the *jhum* cultivated crop due to the reduction in the weight per boll. In addition to the cotton, 10 maunds of paddy and one maund of *til* are harvested in the mixed crop of *jhum*. The range of cotton yields obtained in the three States of the region is given in Table 163.

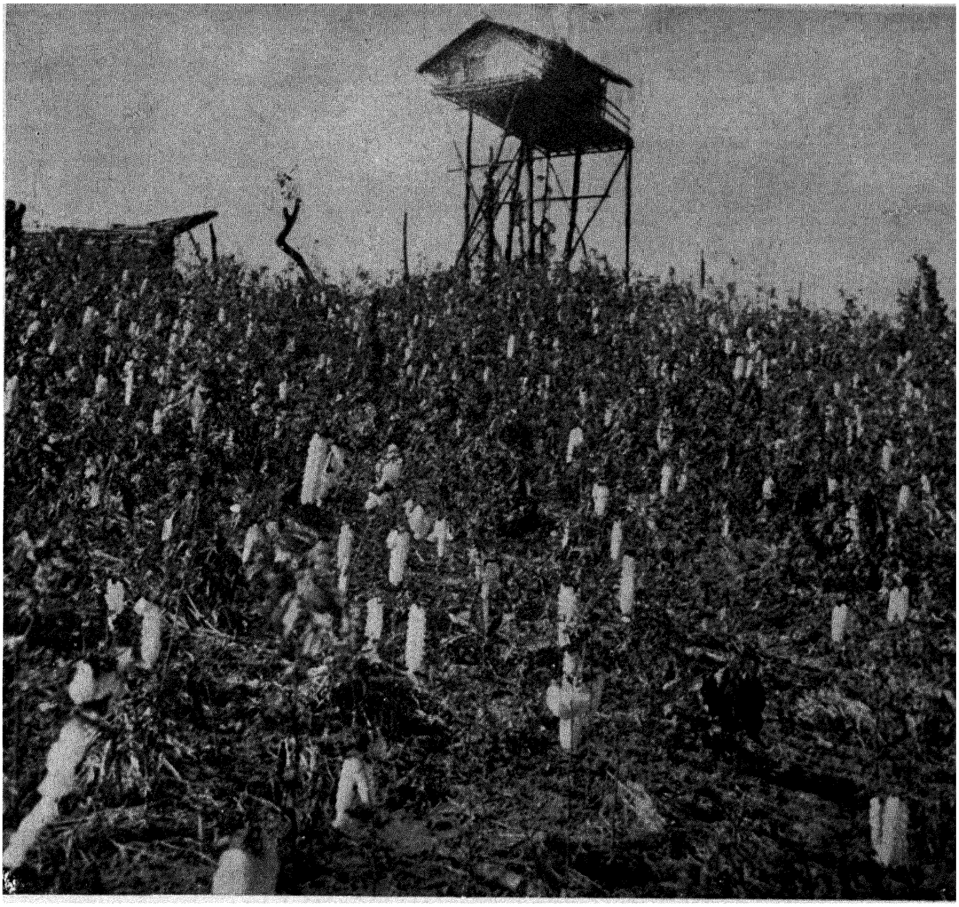
TABLE 163. RANGE OF COTTON YIELDS

State	Type of cultivation	Yield per acre (lb.)	
		Cotton	Paddy
Assam	*Jhum* (mixed)	250- 300	700- 900
Orissa	Monsoon—*desi* (pure)	100- 200	
	Monsoon—American (pure)	300- 600	
	Rabi irrigated-American (pure)	400- 600	
Bengal	Monsoon—American (pure)	800-1,000	
	Monsoon—American (mixed)	600- 800	1,000-1,200

Cotton grown in the Eastern Region is largely of short staple varieties as shown in Figure 38.

MARKETING AND GINNING

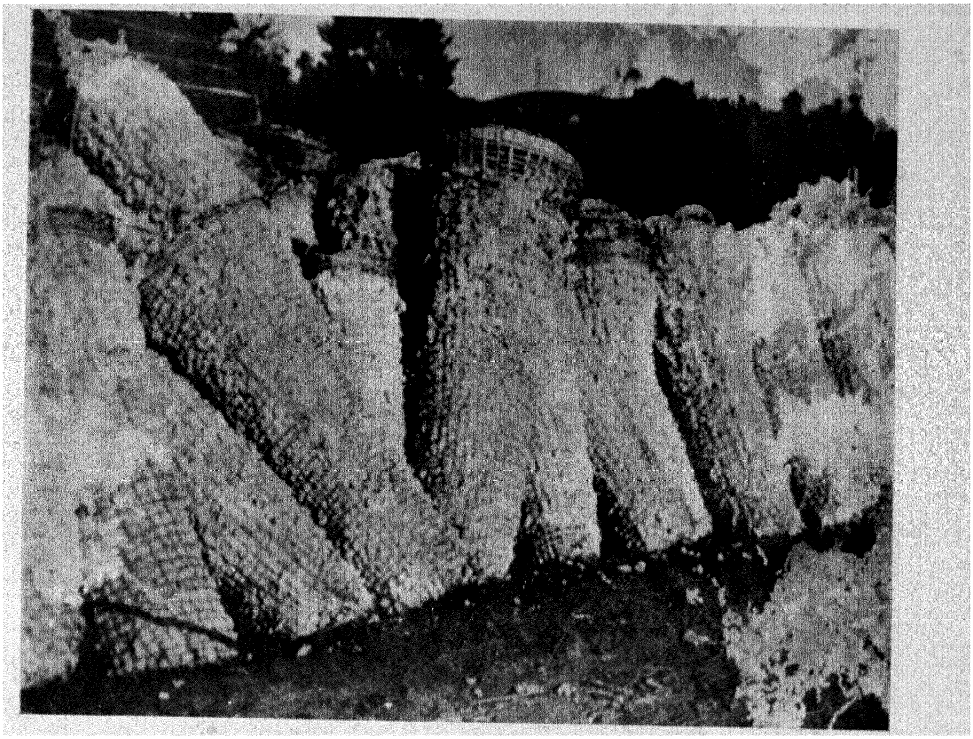
There is no organised marketing in the region. In the hills, cotton is carried in a conical basket called *thurung* (Plate XIX) which is strapped across the head. The entire quantity is sold in the bazar (Plate XX). The balance used for weighment is either spring type or locally manufactured tripod design.



Crop Sown on a Hill Slope

PLATE XVIII

A Close View of the Crop



Cotton Stored in *Thurungs*

A Typical Cotton Market

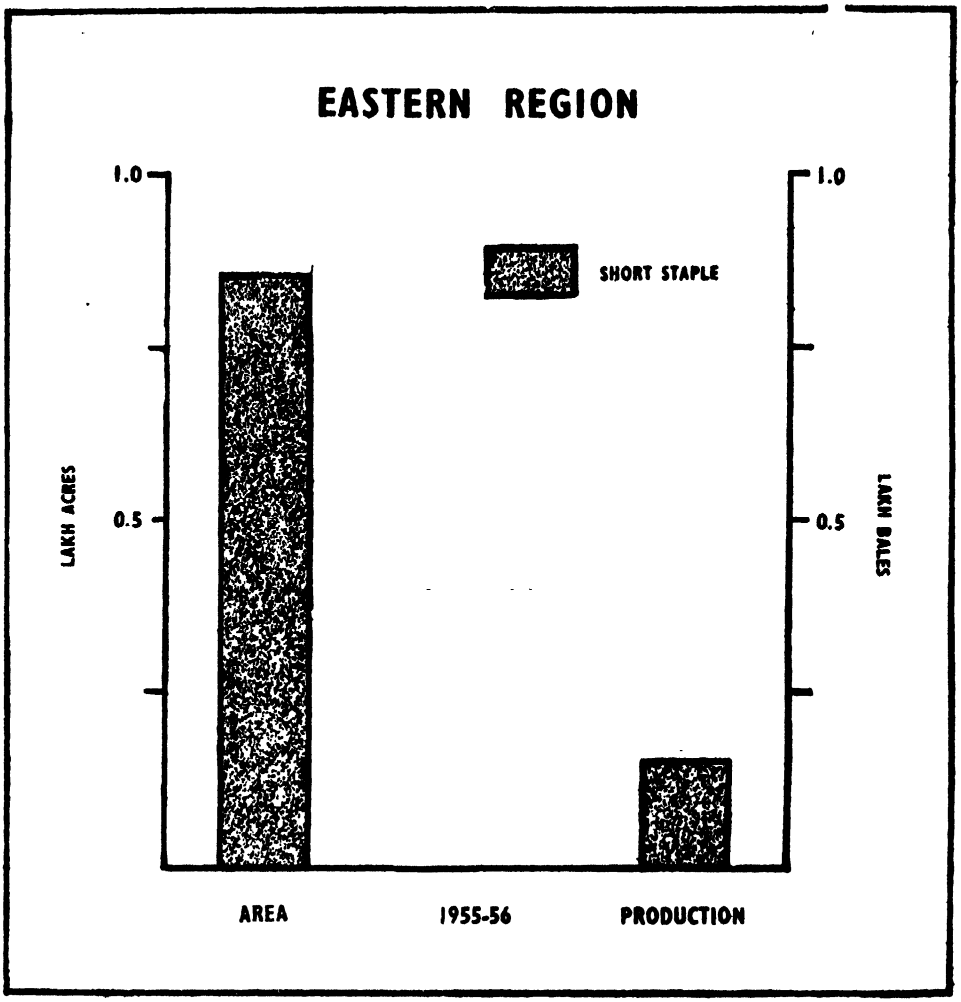


Fig. 38. Staple-wise Area and Production of Cotton in the Eastern Region—1955-56

Hand-ginning, which was in vogue in the earlier years has now disappeared completely. A miniature ginnery was working with the aid of water power in Assam, but at present the whole of the produce harvested in the Garo Hills moves to Dhubri, Mancachar and Salamia from where it is transported by river to Calcutta.

In recent years, the Co-operative Central Marketing Body has been organising the pooling and marketing of cotton grown on the Garo Hills by fixation of fair prices and encouraging cotton cultivation.

ECONOMICS OF COTTON PRODUCTION

Since the whole of the Eastern Region is not a major cotton area and since cultivation is mostly done by family units without engaging hired labour, it will be very difficult to assess the economics of cotton production. Comillas are generally in good demand and priced high at values in the vicinity of Rs. 1,400 per candy (784 lb.) of lint. A rough idea of the cultivation expenses and the gross return per acre are given in Table 164.

TABLE 164. ECONOMICS OF COTTON CULTIVATION

State	Cultivation expenses per acre (Rs.)	Gross values per acre (Rs.)	
Assam	Family labour	Cotton	60
		Paddy	80
		Total for *Jhum*	140
Orissa	100		200
Bengal—Central	200		400
Bengal—West	100		250

SEED MULTIPLICATION—UTILISATION OF COTTON SEED—COTTON LEGISLATION

There is no seed multiplication scheme in the States comprising the Eastern Region. The seeds sold by the merchants in the bazar are freely used for sowing. The requirements of a State like Orissa, where the area under long staple American cotton is increasing and where new tracts are brought under canal irrigation, are met by imports of improved varieties from other States in India growing the particular type of cotton.

Cotton seed is not used for cattle feeding and as such all surplus seed finds an outlet through Calcutta, either for oil extraction or despatch to places where the seed is normally fed to cattle.

Since the entire region is of minor importance in the matter of cotton production, no legislation has been enacted for the regulation of ginning, pressing, transport or cultivation of cotton.

FUTURE POSSIBILITIES FOR EXTENDING CULTIVATION

Considerable expansion of the area under cotton is expected in Bengal and Orissa, when the new irrigation projects are completed. In Bengal, Kangasabubati and Swarnbansi Projects will bring in 20,000 acres under cotton. Under the Hirakud Dam in Orissa, 1,00,000 acres will be put under *kharif* cotton in the districts of Sambalpur and Bolangir. There are also great possibilities for growing an irrigated crop in *rabi* season in *mal* lands after the harvest of paddy and other short duration crops. The *bahal* and *buna* lands, lying fallow from December to June, are likely to lend themselves for growing cotton by the development of a suitable short-duration variety. The three types of lands named above and situated in Sambalpur and Bolangir districts are potential areas for developing about 20,000 acres in no distant future. In the Delta zone of Cuttack and Puri, about 30,000 acres can be developed for cotton in *rabi* season after the harvest of paddy.

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